The American Journal of Surgery

NEW SERIES, VOL. X DECEMBER, 1930 No. 3

RECONSTRUCTIVE SURGERY

IN UNILATERAL PROGRESSIVE FACIAL HEMIHYPERTROPHY*

H. L. UPDEGRAFF, M.D.

HOLLYWOOD, CALIF.

THE problems of the reconstructive surgeon are sometimes of general interest and the fact that Osler's "Practice of Medicine" gives but a single line to the mention of unilateral progressive facial hemihypertrophy urges me to detail an attempt at surgical reconstruction of such a case referred to me by Dr. E. F. Tholen. The condition referred to is a unilateral enlargement of one-half or side of the face including all or a part of the bony as well as the soft structures.

When I first saw the patient (Fig. 1) and made a working diagnosis, I tried to confirm it by a casual search through the textbooks at hand, which proved unsuccessful until a reference in Dana's "Diseases of the Nervous System" brought to light a case with an illustration similar to my patient. Dana referred to his patient as the eleventh reported case. A search of the literature brought numerous references to facial hemiatrophy but very few to unilateral facial hemihypertrophies, the earliest being that of Beck[1] in 1836. I found my interest lay not only in the rarity of the case but in the possibility of surgical reconstruction with cosmetic improvement. The thought of possible recurrence or stimulation of the condition following operation, elicited from the available literature the fact that only one such reported case of a patient had been operated on and that one not for cosmetic pruposes, but for relief of pain from the growth of the superior maxillary bone.

Montgomery's[10] case report in 1893 is of interest in that in his article he states: "the interest in these cases lies in their exceeding rarity, it is by the careful reporting of such cases whenever found that some future collaborator may be enabled to draw valuable inferences." I am indebted to him for a list of cases[1–9] preceding his, which from checking the early literature I find to be acceptably accurate and am including in my bibliography for the assistance of tomorrow's collaborators. His case however was not congenital, having first been noticed at ten years of age. The tongue was not hypertrophied but the usual accompanying pigmented nevus was present on the left cheek.

Dana's[11] case was that of "The Giant Wilkins" who came under his observation in the early nineties and who was later reported again by Peter Bassoe[12] who took care of him during his final illness and published the post-mortem findings. The studies of these two men established the condition as an entity by differentiating it from acromegaly. They however called attention to the fact that it sometimes appeared in conjunction with acromegaly and giantism.

Werner's[13] case reported in 1904 was:

A male aged twenty-four with a negative family history and a congenital hypertrophy of the left side of the face. His general condition was normal, and he was of medium size. The hypertrophy included the upper jaw, cheek, lips, lower jaw as well as the teeth, tongue and

*Read before the Joint Meeting of the San Luis Obispo and Santa Barbara County Medical Societies, at Santa Maria, Calif., July 14, 1930.

tonsil. It appeared as if the anterior half of the skull was formed with a large left side and a smaller right. The left angle of the mouth was drawn downward, so that about 5 mm. of the left half of the lower lip was obscured. On the anterior surface of the neck there was a dark pigmented area which was somewhat elevated, with irregular margins and enlarged papillae, but without increased growth of hair.

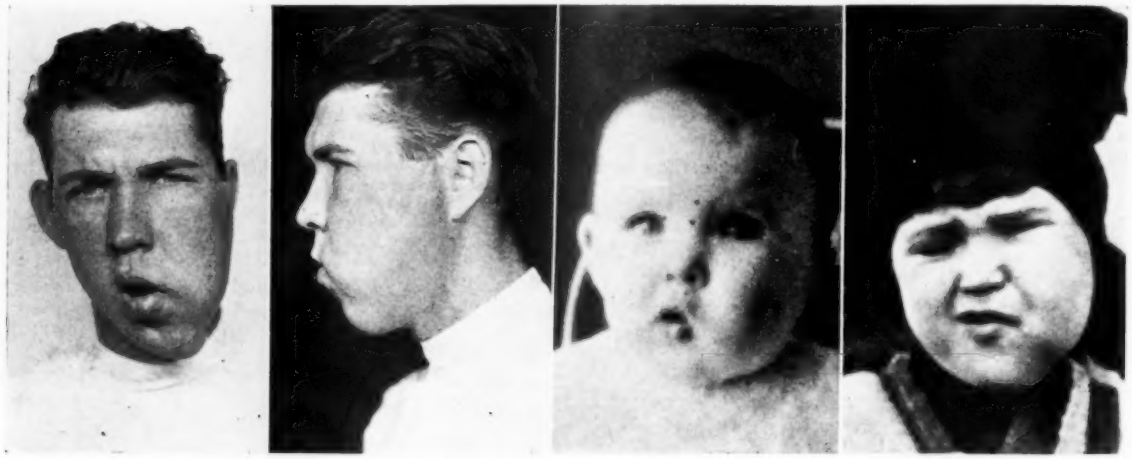

Fig. 1. Fig. 2. Fig. 3. Fig. 4.

Fig. 1. Facialis unilateral hemihypertrophy at twenty-one years.
Fig. 2. Hemihypertrophy of both soft and bony structures.
Fig. 3. Congenital hypertrophy at three months. Same case as Figs. 1 and 2.
Fig. 4. Progressive enlargement at five years. Same case as Fig. 3.

It is more than interesting to note that every detail of the foregoing is duplicated in the present reported case (Fig. 2) even to the peculiar incidence of the pigmented nevus on the neck which Werner quotes as an argument against macrosomy developed on the neurotic basis.

Mackay[14] in 1904 in presenting a case of acquired hemihypertrophy lists 19 congenital cases and calls attention to the fact that in all 19 cases the parts affected corresponded exactly to the distribution area of the fifth nerve.

Welt-Kakels[15] in 1914, in discussing her reported case called attention to the hemihypertrophy of the tongue as an evidence of congenitalism.

It would seem that up to the present, there are approximately 25 or so reported cases with enough similar points to give a rather definite clinical picture of congenital facial unilateral progressive hemihypertrophy, and render it a textbook entity. To this picture of the disease, of which much has been said etiologically and pathologically, I would like to add a contribution toward therapy in the form of reconstructive surgical measures which in the following case have proved satisfactory.

My patient is a lad of twenty-one, husky, 6 ft. 3 in. weighing 170 lb., recently graduated from high school, well up in his class, with a desire to teach agronomy in the junior high school. His facial appearance constituted a handicap in dealing with youngsters and he came to me in hopes of benefiting his appearance and aiding his mastication.

His family history is negative. His father is a well-developed man of 6 ft. 1 in. and his mother at the time of his birth was healthy and normal, having in late years developed a chronic arthritis. He had a normal birth but it was noticed that there was a hypertrophy of the left face as shown by his baby picture at three months (Fig. 3). His childhood on the farm was uneventful and his picture at five years of age (Fig. 4) shows a progressive unilateral facial development.

The general physical examination disclosed no abnormalities aside from the facial condition and it was the consensus of familial opinion that there had been "no change in the face for at least five years."

Aside from the special examination reports that follow, the striking points of interest in the left face are the variations from normal.

Fig. 5. Fig. 6.

Fig. 5. Showing bony involvement in same case as Fig. 1.
Fig. 6. Note mandibular overgrowth. Same case as Fig. 2.

The left cheek is of rather firm consistency, does not pit and is about 5 cm. thick and measures 7 cm. larger from the philtrum to the tragus.

There is a pigmented nevus on the left neck some 6 cm. in diameter.

Fig. 7. Mask of face before operation.

The beard is normal on both sides.

The left lips are markedly enlarged and the left corner of the mouth pouting and pendulent with the angle drawn downward.

The mouth opens normally but seems to gape toward the right.

The left tongue is a half larger than the right.

The left upper and lower molars have been removed in an effort to allow the mouth to close and the gums are touching at the posterior portion.

The left mandible seems to slope inward.

Fig. 8. Composite model of jaw.

The left superior maxilla is markedly displaced toward the center line and the palate is very high.

Dr. M. Russell Wilcox kindly examined the eyes and found the vision normal and no evidence of intracranial pressure or sella turcica involvement. The nose interior was normal with the exception of the pushing to the right of the septum. The ears were normal except for a symmetrical enlargement of the left one. The left antrum transilluminated poorly but there was no history of infective activity.

Dr. Wm. D. Napheys reported in his *neurologic examination* as follows: "Lower portion of left side of face much larger than right, soft and bony structures both involved. Lower jaw prognathous and deviates to left. Tongue when protruded deviates to right and left half of same is much larger than right half. Other facial muscles function equally on both sides, as far as trophic asymmetry will permit judgment. There is a slight, fine, rapid tremor of tongue, eyelids and fingers. Romberg's sign not present. No paralysis or paresis of muscles of face or elsewhere over body. Reactions to electric stimulation were not normal and equal on both sides, but were not typical of the reaction of degeneration. There was a slight modal change present, the faradic current did not produce as much contraction when applied to the muscles on the left side as on the right. In contrast to the usual quantitative changes, faradic stimulation of the left facial nerve produced a more marked response on the left side than on the right. There was no qualitative change, in that galvanic stimulation of the

muscle produced an equal response on both sides. There was no polar change present, the negative galvanic irritation of the facial nerve producing a more marked response than the positive on both sides.

There was no sensory change present in either side of the face and the special senses were all normal. No disturbance of superficial or deep reflexes was present. Subject showed a normal mentality and except for a slightly unusual response to electric stimulation of the face, which might be interpreted as an anomalous partial reaction of degeneration and hemifacial hypertrophy indicative of trophic change, the neurologic findings were negative."

From an *x*-ray standpoint there was much to be learned (Figs. 5 and 6). The sella turcica was normal in size and shape according to Dr. Benj. H. Sherman the radiologist. The skull was normal while large, with the exception of the left lower face. The hypertrophy involved the left mandible from the midline showing a bony structure of normal density but twice as large as the right side in all dimensions except the longitudinal. The left lower front teeth were somewhat enlarged and there was an exostosis forward to the left of the midline of the mandible. The left upper and lower back teeth had all been previously removed and an alveolectomy performed with good results. The left superior maxilla was pushed inward to the extent of making practically a straight line from the midline at the incisor teeth to the molars, such distortion evidently having been caused by the overgrowth of the mandible. The left antrum was cloudy. The zygoma and orbit were normal. The nasal bones and the nasal process of the superior maxilla were pushed to the right giving a distortion to the right of the septum and entire nose.

The *laboratory findings* were of interest in that they showed no marked abnormalities except a rather high hemoglobin of 1.24 (Sahli) with a 1.1 plus color index. The pituitary hormone in the blood as checked by R. S. Willard, Ph.D., was 13 mg. per 100 c.c. as against a normal of 11.4. Following are the reports of Dr. V. L. Andrews of the Hollywood Hospital:

Blood:

Leucocytes	9,000
Polymorphonuclears, per cent	69
Erythrocytes	5,200,000

Blood Chemistry:

N. P. N.	40.5
Uric acid	3.0
Sodium chlorides	220.0
Sugar	67.8
Sodium	1,075.5
Calcium	20.1
Potassium	18.2
Magnesium	3.1

Phosphorus:

Inorganic	2.247
Inorganic and hydrolyzable	1.559
Acid solution	7.410
Total	11.216

Fats:

Cholesterol	250.
Lecithin	200.
Fatty acids	25.
Neutral fats	0.
Total	475.

Amino-Acids:	8.4

Enzymes:

Pepsin	.0
Trypsin	.0
Lipase	.0001
Amylopsin	.0001

Urine:
Negative throughout

Basal Metabolism Rate:
Normal to less than ½ per cent
T. 97.2 P. 72 R. 18

Wassermann Test Negative:.

The question then of differential diagnosis involves, the ruling out of hemiatrophy because of the absence of atrophic changes on the right or smaller side. Acute swellings need not be considered on account of the history. Acromegaly is excluded by the characteristic general symptoms being absent; hemangioma, by persistent size on change of posture and character of cheek tissue; partial macrosomy, by the history, leontiasis ossea, by absence of typical bony deformity. The involvement of the soft parts speaks against diffuse hyperostosis.

The hemilateral enlargement of the bony as well as the soft structures, with an authenticated history from birth, with the elimination of possible conflicting diagnoses, leaves the diagnosis of congenital unilateral progressive facial hemihypertrophy with possibly a mild giantism, the title of choice.

It was the opinion of the consultants that there was no contraindication for operation except lack of precedent and preparations were made accordingly.

A preliminary plaster mask (Fig. 7) of the face and a composite model of the jaw (Fig. 8)

from actual measurements revealed a ridge of bone on the left lower edge of the mandible some 12 cm. in length and from 1 to 15 mm. larger than the right side. Under trachel intubation and colonic-ether anesthesia, a semilunar incision was made from a point 3 cm. to the right of the midline of the mandible and 3 cm. posterior to the point of the chin to a point opposite the aural canal. The skin was freed and elevated to the lip border and as far forward as the zygoma. A large amount of hypertrophic fatty tissue interspersed with connective tissue bands was removed from the cheek. The excess bone was sectioned at the lower edge of the mandible with a rotating electric saw and the facial skin brought down and refitted over the face.

It was found that the new closure would entail the removal of an elliptical strip of skin some 15 cm. in length and 4 cm. at its greatest width. Rubber-dam drains were employed and the excision closed by interrupted sutures. Pressure and icebags allowed healing by primary intention and there was an early establishment of cutaneous sensation (Fig. 9). The pathologist's report on the section of bone removed was that it compared favorably with normal bony tissue. The skin and fatty tissue removed did not show any abnormalities. The section of epithelium was of normal thickness.

The parotid was enlarged and the intraoral opening of Stenson's duct was somewhat forward and lower than ordinary. The left mental foramen of the mandible instead of being opposite the first and second lower bicuspids appeared at the point opposite and below the second molar. The dental canal was represented by a groove running along the canal's usual bed and lying in it, the mandibular dental branch (which was of necessity sectioned) measuring 5 mm. in diameter.

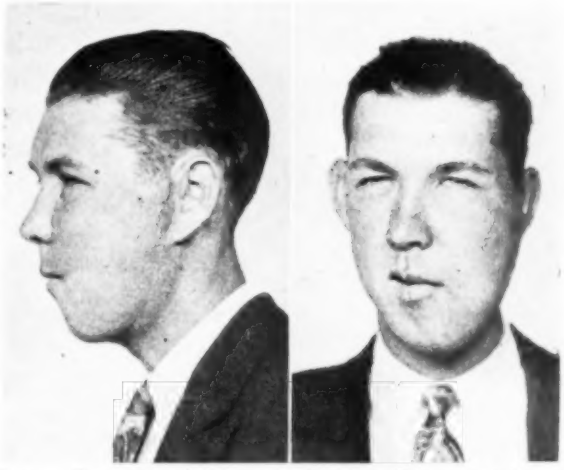

Fig. 9. Postoperative, sixty days.

Fig. 10. Postoperative, six months.

Three months later the exostosis of the incisor area was removed intraorally and a portion of the upper lip resected. Dr. Leigh Faul constructed the necessary upper and lower plates and the patient was allowed to proceed with his instructionship. There has been some recurrence of the fatty deposit in the left cheek (Fig. 10) and the patient has gained in weight. I think that sea sponge pressure over the cheek for a period directly postoperatively would have been a help. There has been no recurrence of the bony growth and the jaw has healed smoothly.

With this experience I can see no reason why similar cases should not be operated once they have reached maturity.

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HOW WAVES GO DOWN THE BOWEL*

WALTER C. ALVAREZ, M.D.

ROCHESTER, MINN.

IN view of the fact that conduction along the muscular wall of the intestine is one of the most important functions in the body it is all the more remarkable that today practically nothing is known about it. The main reason for this ignorance is that thirty years ago physiologists throughout the world accepted unanimously and without reservation a misquotation and a misunderstanding of the statements of W. M. Bayliss and E. S. Starling. These men observed that if they cut the vagus and splanchnic nerves of a dog and then purged and anesthetized him, stimulation at a point on the small bowel would *sometimes* cause contraction orad and relaxation caudad. They had difficulty in showing this "reflex" in the cat, and they were practically unable to show it in the rabbit.

In spite of the fact that the few men who later attempted to confirm these observations had difficulty in doing so, and in spite of the fact that later Cannon warned the medical world that this "reflex" probably had nothing to do with several of the most important phases of gastrointestinal peristalsis, the writers of textbooks promptly brushed away all doubts; they quoted Bayliss' and Starling's principal statement without its important restricting clause, and as a result the "law of the intestine" became one of the foundation stones of physiology about which there appeared to be no further question. The fact that the phenomenon was inconstant and hard to elicit; that it was hard to elicit in the cat and almost impossible to elicit in the rabbit; that it was present only in denervated and purged bowel, and that records made with the bowel of man failed to show it, all this was ignored and forgotten, and students were taught and are being taught and will doubtless be taught for another fifty years that in all normal animals all stimuli produce contraction above and relaxation below, and this is why waves go down the bowel.

Actually, if one takes a normal rabbit or a rabbit with vagus and splanchnic nerves cut, and stimulates the bowel with an electric current, one gets almost always contraction at the point stimulated and also above and below. Occasionally there will be seen a momentary inhibition but, as Bayliss and Starling found, this inhibition will sometimes appear above as well as below the point stimulated.

The stimulus appears to act much as a stone does when it is thrown into a pond; from the local disturbance ripples spread out on all sides. In the bowel of the rabbit a wavelet of some kind ordinarily runs orad for a distance of from 3 to 15 cm., and caudad for a distance of from 3 to 20 cm. It almost always goes farther caudad than orad, and it seems to travel a little faster cauded than orad.

There is considerable evidence to show that this wavelet travels along the nerve fibers in Auerbach's plexus. Thus, if one makes a circular cut through the muscle down to the mucous membrane and allows it to heal there will later be no sign of conduction of electrically produced wavelets past the scar. Peristaltic rushes will easily jump the gap because, as I showed years ago, they push a column of fluid ahead of them, and the distention produced by this column causes a new rush to start on the other side of the obstruction. One can actually cut the bowel in two and join the ends with a piece of glass tubing without interrupting in the slightest the progress of peristaltic rushes down the bowel. If it were not for this mechanism, the maintenance of life after end-to-end or

* Read before the Thirty-third Annual Meeting of the American Gastro-Enterological Association, Atlantic City, May 5 to 6, 1930.

side-to-side anastomoses of the bowel would probably be impossible.

Besides the impulses which travel slowly through the neurones in Auerbach's plexus there are others which travel rapidly by way of long nerve paths in the mesentery or in the bowel. My records of intestinal activity, made simultaneously from many parts of the bowel, show that often when a peristaltic wave starts on its way down the duodenum the lower ileum will almost immediately begin to contract so as to keep the intestinal contents from going on too rapidly into the colon. Although I have not been able to demonstrate it in my records I suspect that there is also some coördinating influence which speeds ahead of the rush wave and smooths the way for it because the excised bowel behaves so differently from the intact bowel when one injects fluids into the orad end. In the living rabbit, such fluid, even in the absence of waves, will seep rapidly caudad, while in the excised bowel it can be forced through only slowly and with difficulty. Similarly if one bathes a loop of bowel from a living animal in a weak solution of nicotine the rhythmic contractions which tend normally to spread caudad become incoördinated, the muscle shortens here, there, and everywhere about the same time, and the bowel takes on the appearance of a string of beads.

There is much evidence now to show that, at least in the chicken, Auerbach's plexus is made up primarily of a chain of neurones each about 10 cm. long. Between them, perhaps, are valve-like synapses much like those in the central nervous system, synapses which make it easy for impulses to travel in one direction but almost impossible to travel in the other. These nerves in the bowel are different from those elsewhere in the body; they probably have a very slow rate of metabolism because they conduct so sluggishly (about 5 cm. a second) and because they can live so long after the circulation is shut off. The nerve cells in the brain and spinal cord are destroyed or irreparably injured after ten minutes of anoxemia but, as Cannon and Burket have shown, the nerve cells in Auerbach's plexus will survive periods of anoxemia lasting three hours or more. Experiments which my assistants and I are now performing indicate that what Cannon and Burket found in the cat is true also for the rabbit, and the surgeon here has an explanation for the fact that bowel freed from incarceration in hernial openings will often survive and regain its function after surprisingly long periods of strangulation.

One of my reasons for deciding to spend several years in the study of conduction in the bowel and in an attempt to analyze the structure of Auerbach's plexus was my desire to understand something of the mechanism underlying certain types of dynamic ileus. Every so often a surgeon who has had to open an abdomen on account of signs and symptoms of intestinal obstruction will find at the caudad end of a distended loop a ring of muscle which, except for the fact that it remains contracted, appears to be perfectly normal. What has gone wrong? Occasionally such rings will relax at the time of operation but sometimes they do not, and the only way in which to cure the patient is to excise the contracted region. A similar type of contraction seems to account also for the obstruction in many cases of Hirschsprung's disease.

Although as yet I have little evidence to back up my theory it has long seemed probable to me that these contraction rings must be due to a loss of function in the neurones in Auerbach's plexus which are connected with the muscle fibers. As Nolf has pointed out, there is considerable physiologic and anatomic evidence to show that Auerbach's plexus consists of two types of nerve cells: one group perhaps concerned with the maintenance of good conduction along the bowel, and the other group connected with the muscle fibers. Besides those two sets of neurones, with their axones and dendrites, there are, in Auerbach's plexus, innumerable fibers of

vagal and splanchnic origin. That the vagal fibers are of little importance in conduction was shown recently by Hosoi and me. We cut the vagi, allowed time for degeneration, and then found that, except in the lower part of the ileum, conduction was unimpaired. Degenerative section of the splanchnic nerves interfered considerably with the conduction of electrically produced disturbances, but the rush waves continued to travel normally down the bowel, and some of the animals lived and gained weight.

Incidentally, we saw no sign of that antagonism or balance between the vagus and splanchnic nerves which is so dear to the heart of medical theorists. Cannon saw no sign of it during the years in which he was removing the sympathetic nervous system from cats. Unfortunately for the theories of clinical writers the statement found in all textbooks to the effect that the vagus is the motor nerve for the bowel and the sympathetic the inhibitor is wrong. As usual with such clear-cut statements, it contains a grain of truth, but anyone who will take the trouble to perform a few experiments or to look through the literature will soon see that the problem is not so simple. The nerves are bundles of all sorts of fibers and for this and other reasons the effects obtained when they are stimulated are complicated and variable.

One can destroy the conducting function of the first group of neurones in Auerbach's plexus either by giving nicotine or by shutting off the supply of oxygen, but it is hard to know how to destroy the function of the second group without at the same time injuring the muscle. At first sight it should be easy because we know that the excised muscle will beat rhythmically and normally after it has been kept for four or five days in an ice box, and it does not seem probable that even the remarkably hardy nerve cells of the myenteric plexus could live that long. Unfortunately we do not know yet how long they can retain their functions when the tissue is kept cool, and it may be that under these circumstances they can live for several days.

At present I am trying to find a period of anoxemia long enough to destroy the nerve cells but not long enough to destroy the muscle. I believe it can be found because surgeons occasionally discover that a loop of bowel which has been strangulated for a long time, or which has lost its connection with the mesentery, will survive, only to contract later to a hard narrow tube. My reason for believing that this phenomenon is due to the loss by the muscle of its immediate nerve supply is that experiments on lower forms of life have shown that such a loss will produce a form of spastic paralysis: the muscle separated from its ganglion cells contracts down into a hard knot and stays that way.

From what is known now of Auerbach's plexus it seems probable that certain forms of paralytic ileus might easily be due to the deleterious effect of some toxin or some inhibiting influence acting on the very vulnerable synapses between the first group of conducting neurones. Such an injury would leave the segmenting activity of the bowel unharmed but would perhaps put a stop to the peristaltic rushes.

I regret that in this short paper I have not answered the questions with which I started but if perhaps I have shaken the faith of my readers in some of the statements that have heretofore lulled them into a sense of false security, and if I have stimulated them to think more about these problems of intestinal function I will have done something of what the Program Committee asked me to do.

I would strongly recommend to all those who think they know something about the innervation of the bowel that they read Van Campenhout's recent review of the attempts that embryologists have made to clarify the problem. At present there are seven who claim that the nerves of the bowel arise from the mesoderm; four are sure that these nerves come from vagal

primordia, and fourteen are equally sure that they are of sympathetic origin. In this world of science it seems as if only the writer of textbooks can arrive easily and promptly at the truth.

SUMMARY

Faradic stimulation of the small bowel of the rabbit causes a disturbance to spread out from 3 to 20 cm. orad and caudad. As a rule these wavelets travel slightly farther and faster caudad than orad and they almost always cause contraction of the muscle. There is rarely any sign of Bayliss' and Starling's law in the bowel of the rabbit.

There is considerable evidence to show that conduction in the bowel takes place by way of neurones in Auerbach's plexus. The synapses between these neurones are probably valve-like and favor conduction in the caudad direction; they appear to be highly susceptible to anoxemia because in the rabbit peristaltic rushes disappear immediately after the death of the animal. They are susceptible also to the action of nicotine.

The nerve cells are remarkably resistant to anoxemia as shown by the fact that in the cat they do not seem to lose their function when the circulation is shut off for five hours. Certain forms of paralytic ileus may perhaps be due to a blockage by toxins or by nervous inhibition of the synapses between the conducting neurones in Auerbach's plexus. Tonic contraction rings which sometimes produce intestinal obstruction may well be produced by a loss of function in another group of neurones which presumably are attached directly to the muscle.

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DIET AFTER OPERATIONS ON THE STOMACH*

ALBERT F. R. ANDRESEN, M.D., F.A.C.P.

BROOKLYN, N. Y.

THE average surgeon, after performing an operation upon the stomach, gastroenterostomy, partial or subtotal gastrectomy, pylorectomy or any other procedure, will leave orders for the patient to have nothing by mouth for twenty-four or forty-eight hours, or if liberal in regard to feedings, will allow sips of water or cracked ice for a day or two and then add broths, tea or lemonade for a few days, followed by a rather rapid increase to a too liberal diet. Often the patient is discharged from the hospital with permission to eat everything. The bad results of this irrational and careless method of treatment are constantly being encountered, and it is time to suggest a remedy.

In order to rationalize postoperative diets it is necessary to consider the conditions that present themselves. As ruthless surgery for ordinary small peptic ulcers is gradually being abandoned by conservative surgeons, it means that the candidate for operation has either a carcinoma or one of the complications of an ulcer: stenosis, perforation or a large indurated ulcer which has bled and requires operation. The patient is therefore, as a rule, a poor operative risk. In partially obstructive cases, preoperative feeding of small quantities of concentrated foods, milk, cream and lactose mixtures, at short intervals, will often, in a week or ten days, transform an exceedingly bad risk into a fairly good one. Rectal feedings of glucose and alcohol, and subcutaneous or intravenous injections of saline or glucose, will further help to improve the operative risk. Nevertheless the operative patient is usually much under weight, has been more or less starved for some time, and presents a picture of dehydration and even acidosis. His gastrointestinal tract, having become unaccustomed to propelling normal quantities of content, is in a condition where postoperative ileus is to be anticipated. The Murphy drip, while of inestimable value in these cases, is not always sufficient to save life, and lavage, enemas, stupes and medication are often not of use in preventing or combating ileus.

The ideal gastric operation is one done under local, block or spinal anesthesia, avoiding the shock, dehydration and postoperative starvation period attendant upon general anesthesia. The ideal postoperative treatment would consist of measures to prevent or treat shock, the early administration of fluids to overcome the already existent dehydration, and the early ingestion of material which would stimulate gastrointestinal motility, thus avoiding distressing distention or ileus. Shock has always been combated by suitable medication and by application of heat externally. The Murphy drip, whether of saline or glucose, when successfully administered, has added unbelievable amounts of fluid to the patient's organism; but how often, unless a special nurse is constantly on the alert, do we not find the fluid in the bed, the patient saturated and the tube causing annoyance, restlessness or even pain?

In an effort to institute early feedings after operation, the writer, twelve years ago[1] reported the successful administration of peptonized milk, cream, dextrose and alcohol mixtures through a Rehfuss tube which had been placed in the patient's stomach before operation, and which had been pushed well into the intestine by the surgeon at the time of operation. Feeding through tube was commenced while the abdominal wound was still open showed that 250 mils of a feeding mixture such as mentioned previously, would result in prompt peristalsis and the rapid passage

* Read before meeting of American Gastro-Enterological Association, May 6, 1930.

of the food through the intestinal tract, even when the patient was under deep general anesthesia. Spontaneous bowel movements occurred within two days after operation, and these patients were generally in remarkably fine condition. Shock, dehydration and postoperative distention were practically always avoided. During the period when this procedure was thus being successfully used, it was found in one case that while the tube had been drawn back early into the stomach by postoperative vomiting, the administration of 250 mils of milk, cream and dextrose mixture every two hours through the tube directly into the stomach had been as productive of good results as the jejunal feedings had been in the other cases. This suggested the desirability of giving feedings by mouth immediately after operation, thus avoiding the trouble, trauma and possibility of infection incident to the opening of the stomach when the surgeon placed the tip of the tube well down in the jejunum. However, it was very difficult to persuade surgeons that immediate oral feedings would be safe. It was pointed out that if the surgeon feared leakage from his wound, the gastric juice which the stomach would inevitably begin to secrete after the operation, would of itself not only furnish a sufficient quantity of fluid to be dangerous from the leakage standpoint, but its digestive effect might possibly be deleterious to the suture material and the new scar. On the other hand, the surgeons pointed out that in the first few days after operation a wound could not stand much strain and that eight or nine days afterward the catgut is practically absorbed, which might cause some loss of strength in the wound. In more recent years the researches into wound healing by Harvey and Howes at Yale Medical School,[2,3,4] have shown that during the first three or four days clean wounds of the stomach wall have almost no tensile strength and that cohesion depends almost entirely on the sutures. After this quiescent period strength increases very rapidly, until at ten days it has almost reached its maximum, and at twelve or thirteen days the wound may be considered to be perfectly healed. The process of healing has been shown to be aided and accelerated by the presence of protein in the stomach lumen.

About eleven years ago we devised a system of postoperative feedings, which has been called the Long Island College Hospital Gastroenterostomy Diet, and which, with occasional slight modifications, has gradually been adopted by our surgical staff, until now it is practically a routine for postoperative gastric cases. This routine is as follows:

DIET AFTER OPERATIONS ON THE STOMACH

No feedings to be given when patient is asleep.

No ice, water or other drinks to be given. Lips may be moistened.

Mineral oil, ½ oz. to be given on second night, and every night thereafter.

First Day:
Feedings every two hours as follows:
Beginning on recovery from anesthetic or three hours after return to ward after operation under local anesthesia.
Gelatin solution: 4 oz.

Second Day:
Feedings every one and one-half hours as follows:
Gelatin solution: 4 oz.
Gruel mixture No. 1: 4 oz. Alternating

Third Day:
Feedings every one and one-half hours as follows:
Gelatin solution: 5 oz.
Gruel mixture No. 1: 5 oz. Alternating

Fourth Day and Fifth Day Feedings, every two hours.
Gelatin solution: 6 oz.
Gruel mixture No. 2: 6 oz. Alternating

Sixth and Seventh Days:
Gelatin and gruel, alternating as on previous days, but add to 3 gruel feedings in day any *one* of following:
1 soft-poached egg,
3 oz. cereal,
custard

Eighth, Ninth and Tenth Days:
Gruel mixture No. 2, 6 oz. every three hours, adding to each feeding any *two* of the following:
3 oz. cereal and cream, 1 soft egg
custard or jello, 2 oz.

Eleventh Day and thereafter:
Long Island College Hospital Ulcer Diet

The formulae mentioned in the diet are as follows:

FORMULAE FOR FEEDINGS AFTER OPERATION

	Ounces	Grams	Calories
Gelatin solution:			
Gelatin	1	30	110
Lactose	3	90	360
Juice of 1 orange	..	....	40
Water	32	1000	
Gruel mixture No. 1:			
Cereal gruel (Oatmeal, barley or cornmeal)	16	500	125
Milk	14	420	280
Cream	4	120	480
Lactose	3	90	360
Gruel mixture No. 2:			
Cereal gruel (Oatmeal, barley or cornmeal)	12	350	100
Milk	32	1000	640
Cream	4	120	480
Lactose	4	120	480

As will be seen from a study of the formulae and the quantity of frequency of the feedings as suggested before, patients on this diet receive in the neighborhood of 600 to 700 calories during the first day, 1200 to 1400 calories the second day, 1400 to 1600 calories the third day, and by the eleventh day are getting 2500 to 3000 calories in twenty-four hours. The quantities of solutions given are not so great as to cause undue tension at the site of operation, are easily taken and promptly pass on beyond the stomach. The ability to take food encourages the patient and improves his morale. The food stimulates the salivary glands, and the amount of liquid given by mouth obviates the necessity for its rectal or subcutaneous administration. All the formulae are soothing to the irritated gastric mucosa and to the wound, all contain some of the protein which Harvey has found to encourage wound healing, all combine readily with gastric juice without overstimulating its production. In addition, the gelatin is a coagulant when applied to bleeding surfaces. With the use of this postoperative diet the improvement in the general condition of the patient is marked, visitors often finding it difficult to believe that a patient has been operated upon the previous day. Spontaneous bowel movements almost invariably occur on the second or third day, even without the administration of mineral oil. Occasionally there is a tendency to diarrhea, due to the large amount of lactose being taken by the patient, and this tendency can be overcome by decreasing or entirely eliminating the sugar. Some patients cannot take the quantities suggested in our diet table, and the size of the feedings may have to be reduced for them. Patients exhibiting allergic reactions from the ingestion of milk or eggs will require substitution of other proteins for these. So rarely does any considerable distention occur, that it is almost unnecessary to mention any treatment for it. A little pituitary extract might occasionally be of use where distention seems to be threatened. If spontaneous bowel evacuation does not occur, a retention oil enema on the third night after operation, if necessary followed by a small soapsuds enema the next morning will initiate subsequent regular daily bowel movements. On the eleventh day after operation, as indicated in the outline given, the patient is put on the Long Island College Hospital Ulcer Diet (shown later)

LONG ISLAND COLLEGE HOSPITAL ULCER DIET

Breakfast:
- Milk, 8 oz. with cream if desired
- Cereal, 5 oz. with milk or cream
- Egg, 1 soft-boiled or poached
- Bread or toast with butter, 2 slices
- Fruit juice or stewed fruit (at end of meal).

Mid-morning:
- Milk, 8 oz. cream, ½ oz. lactose, ½ oz. with cocoa if desired, always with crackers, toast, bread or cake.

Luncheon:
- Milk, 8 oz.
- Baked or mashed potato or plain spaghetti
- Egg, 1 soft-boiled or poached or cream cheese
- Bread and butter, 2 slices
- Pudding, custard, gelatin, ice cream, or stewed fruit.

Mid-afternoon:
- Same as mid-morning.

Supper:
- Same as breakfast or luncheon.

At bedtime and during night every two and one-half hours, if awake: same as at mid-morning:
- Olive oil, ½ oz. three times a day before meals
- Mineral oil, ½ oz. at bedtime
- Water: ad libitum.

which should be continued for a period of three or four weeks, when gradually there

are added all kinds of vegetables and fruits, and an increasing variety of other foods. It must be remembered that in most cases there is no pyloric sphincter action after operation, that food entering the stomach is rapidly passed into an intestine not naturally fitted to receive such unchanged food and that often more or less serious symptoms result from the ingestion of food which is not thoroughly cooked, finely divided and thoroughly masticated. Meat has been found to be particularly prone to make trouble, and should not be added to the diet for at least three or four months after operation, and then very cautiously. Fortunately, in most cases the gastrointestinal tract eventually adapts itself to the new conditions, and then these patients can eat practically normal diets.

CONCLUSIONS

1. Most existent postoperative diets are irrational and add to the danger of operation, to the discomfort of the patient and to the length of the period of convalescence.

2. Early feedings are desirable to encourage the patient and to improve his general condition, to promote wound healing, and to stimulate normal gastrointestinal peristalsis.

3. Feedings of gelatin solution and milk and gruel mixtures are soothing, acid binding and coagulant, and are therefore desirable.

4. Careful dietetic care for several months after operation will prevent discomfort to the patient and complications in his convalescence.

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ROENTGENOLOGICAL STUDY OF THE SUPERIOR AND POSTERIOR MEDIASTINUM*

SAMUEL BROWN, M.D., AND HAROLD G. REINECKE, M.D.

CINCINNATI, OHIO

IN a previous communication[1] our study was confined to the soft structures of the neck. In the present paper we shall deal chiefly with the structures of the superior and posterior mediastinum.

It is our experience, based on a large number of examinations, that no study of the superior and posterior mediastinum is complete unless both the anteroposterior and lateral views are made. Of the two the lateral view often renders more valuable information than the anteroposterior view. In the latter several dense structures such as the sternum, spine, heart, and great blood vessels are superimposed, thus obscuring to more or less degree the soft structures of the mediastinum.

We also find that a true lateral view is of greater value than the oblique view. This is due to the fact that a knowledge of the normal relationship between the various structures in a true anteroposterior and lateral positions is more readily acquired. Thus a deviation from the normal in the relationship of the structures is more easily recognized.

The mediastinum is that portion of the chest which is not occupied by the lungs and pleurae. It is bounded in the front by the sternum and behind by the dorsal spine. The lateral boundaries are formed by the pleural sacs. The mediastinum is divided into a superior and an inferior portion by an imaginary plane which corresponds to a horizontal line drawn from the lower part of the body of the fourth dorsal vertebra to the junction between the manubrium and the gladiolus. The inferior portion is subdivided by the anterior and posterior layers of the pericardium into an anterior, middle, and posterior mediastinum. The anterior mediastinum is in front of the pericardium. The middle mediastinum is within the pericardial sac, and the posterior mediastinum is behind the pericardium and in front of the dorsal vertebrae. In this communication we are interested in the roentgenological consideration of the superior and posterior mediastinum.

The position of the mediastinal structures is essentially due to the equilibrium between the two pleural cavities and the position of the diaphragm. Any change of the position of the diaphragm or any disturbance of the equality of pressure between the two pleural cavities will produce a dislocation of the mediastinal structures. Both local or general causes may be responsible for a change in the position of any of the structures. The local causes will receive our special attention and the structures dealt with will be the trachea, esophagus and aorta.

The position of the trachea, esophagus and aorta as revealed in the anteroposterior view is familiar to all roentgenologists. Any deviation of these structures from their normal course in a lateral direction and the significance which that implies is fully appreciated by all. However, the significance of the exact position of these structures as seen in the lateral view and their deviations in the anteroposterior direction is very much less understood by the average student of roentgenology of the thorax. We shall, therefore, make a detailed description of these structures in the following few paragraphs.

In the lateral view of the thorax, the trachea (Fig. 1 A and B) is recognized on the roentgenogram by its greater transparency in the shape of a narrow column

[1] *Am. J. Roentgenol & Rad. Therapy*, 20: 208–212, 1928.

*Submitted for publication October 11, 1930.

which bisects the superior mediastinum into two almost equal parts. The anterior part is in front of the trachea and is bounded in front by the sternum. The posterior part is behind the trachea and is bounded behind by the dorsal vertebrae. The width of the trachea varies with the age and habitus of the individual. It is usually wider in broad-chested individuals and narrower in individuals of slender build. Occasionally the tracheal rings are readily made out. The course of the trachea from above downward is usually straight with a slight inclination toward the spine. Above, the trachea is continuous with the cervical portion through the superior aperture of the thorax. Below, the trachea is crossed on the left side by the arch of the aorta and below the arch by the pulmonary artery. These vessels obscure the trachea to a greater or lesser degree depending upon the condition of their walls. In case of dilatation of the aorta the trachea may be found displaced to the right. This is best observed in the anteroposterior view. Below the pulmonary artery there is often seen a ring-like shadow due to the origin of the major branches of the bronchi. In front

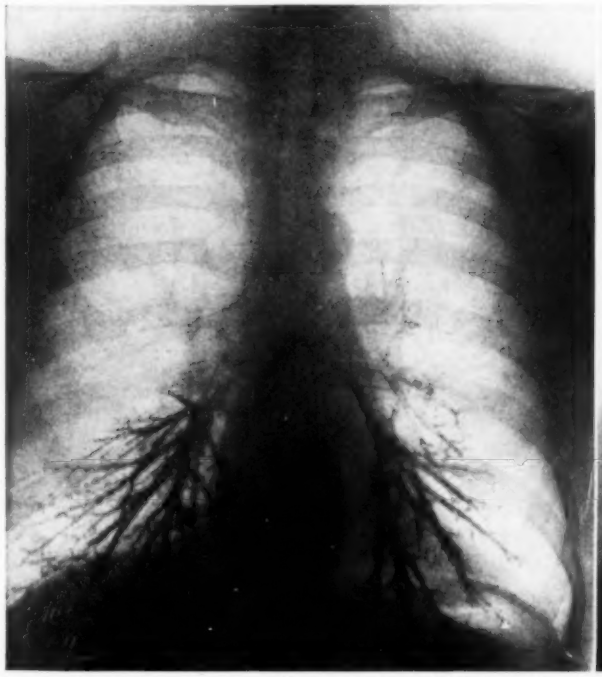

Fig. 1 A. Anterior view. Trachea and bronchi injected with lipiodol. Notice close relationship which exists between trachea on right and arch of aorta on left.

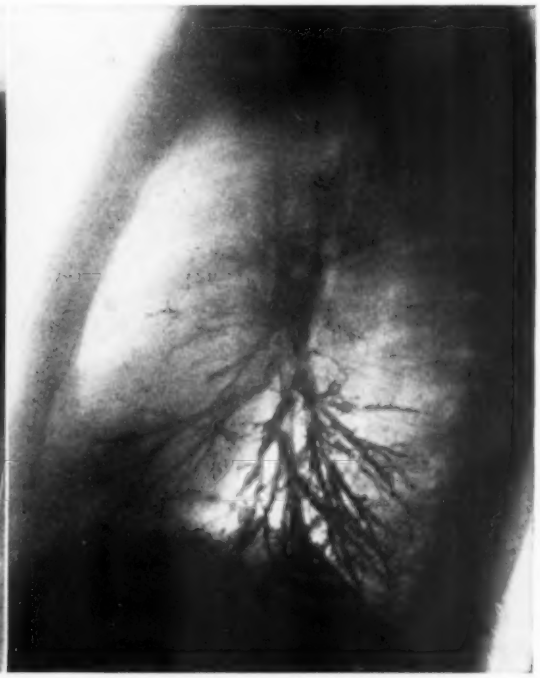

Fig. 1 B. Lateral view. Trachea bisects superior mediastinum into two equal parts. Notice its crossing of arch of aorta. Below arch, trachea is in front of descending aorta.

Fig. 2. Lateral view. Esophageal diverticulum displacing trachea forward.

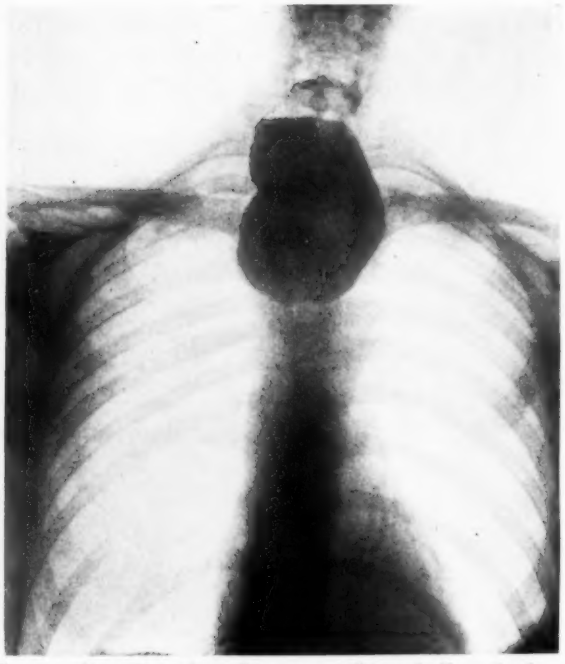

FIG. 3. Anterior view. Large esophageal diverticulum resting upon arch of aorta.

FIG. 4. Lateral view. Forward displacement of trachea by retrotracheal goiter.

FIG. 5. Lateral view. Forward displacement of trachea by dilated esophagus. Contraction of esophagus below arch is due to peristaltic wave.

FIG. 6. Lateral view. Carcinoma of esophagus displacing trachea forward.

of the trachea and above the arch of the aorta there is an area of relatively greater density. Its course is parallel to the trachea and its width is about the same as that of the trachea and is due to the blood vessels arising from the aorta and the veins entering the heart. In front of this area the region is more transparent, which is due to the apices of the lungs.

Under abnormal conditions the trachea is often found to be displaced forward as a result of the presence of esophageal diverticula (Figs. 2, 3). Retrotracheal goiter can only be recognized in the lateral view (Fig. 4) by showing the forward displacement of the trachea. In the anterior view it is impossible to determine its true position. The knowledge of the true position of a goiter enables the surgeon to plan the operation accordingly. Forward displacement of the trachea may result from dilatation of the esophagus (Fig. 5), but this is usually of a temporary nature and depends upon the presence of food above the obstruction. However, there may be permanent displacement as a result of a large tumor of the esophagus (Fig. 6). The distance between the spine and trachea indicates the size of the tumor. In this case the walls of the trachea are not involved but only displaced. Occasionally, in addition to the forward displacement there is also narrowing of the lumen of the trachea as well as distortion of its wall (Fig. 7). The subject of this illustration complained more of dyspnea than of dysphagia. An interesting case of forward displacement of the trachea as a result of retrotracheal tumor due to metastasis is represented by Figure 8. This patient complained of difficulty in breathing. The anterior view failed to show anything abnormal in the chest. The lateral view immediately determined the true cause of the difficulty.

Fistulous communication between the trachea and esophagus is best demonstrated in the lateral view as shown in a case of carcinoma of the esophagus illustrated in Figure 9. The greatest usefulness of the lateral view, we find, is in cases of aneurysm. As a rule an aneurysm is represented by a dense shadow in the anterior

Fig. 7. Lateral view. Carcinoma of esophagus with forward displacement of trachea and distortion of posterior wall of trachea.

view of the superior mediastinum. Its exact origin and its relation to the other mediastinal structures are impossible to determine in this view alone. However, by studying both the anterior and lateral views it is possible to come to a definite conclusion. The anterior view (Fig. 10 A) shows a large circumscribed shadow above the arch of the aorta. In the lateral view (Fig. 10 B) the shadow occupies the posterior portion of the superior mediastinum. The trachea is displaced forward. Evidently the aneurysm is originating from that part of the aorta which is behind the trachea, namely, the upper end of the descending aorta. Postmortem examination of this case confirmed the *x*-ray finding. The next case (Figs. 11 A and B) is just the opposite. The anterior view also shows a dense shadow occupying the superior mediastinum, but the lateral view reveals posterior displacement of the trachea with the

FIG. 8. Lateral view. Forward displacement of trachea and depression of esophagus by metastatic tumor in superior mediastinum.

FIG. 9. Lateral view. Tracheoesophageal fistula.

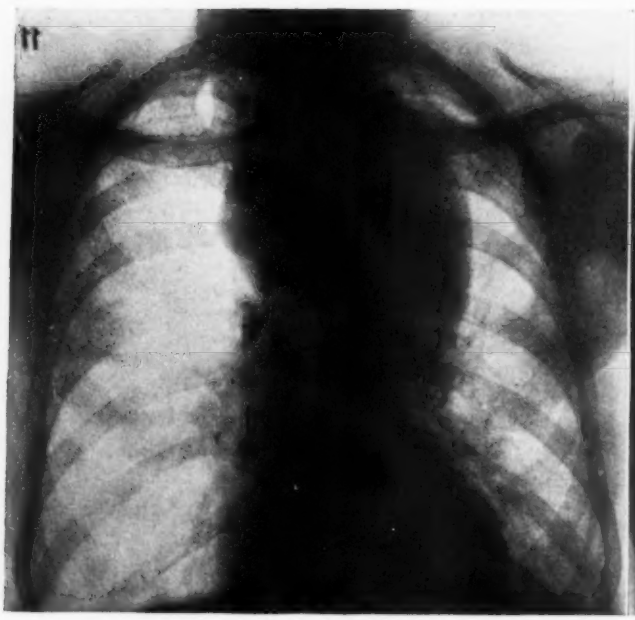

FIG. 10 A. Anterior view. Large circumscribed shadow occupying region of superior mediastinum.

FIG. 10 B. Lateral view. Shadow is behind trachea, which is displaced forward. Evidently, if an aneurysm, it must originate from posterior end of arch or descending aorta. Postmortem examination confirmed this finding.

FIG. 11 A. Anterior view. Large shadow occupying region of superior mediastinum.

FIG. 11 B. Lateral view. Shadow is in front of trachea. Latter is displaced backwards. Evidently, if an aneurysm, it must originate from ascending aorta.

FIG. 12 A. Anterior view. Aorta shows moderate dilatation of arch.

FIG. 12 B. Lateral view. Dilatation of arch is confined to inferior surface. Trachea is depressed and displaced forward. Confirmed by postmortem.

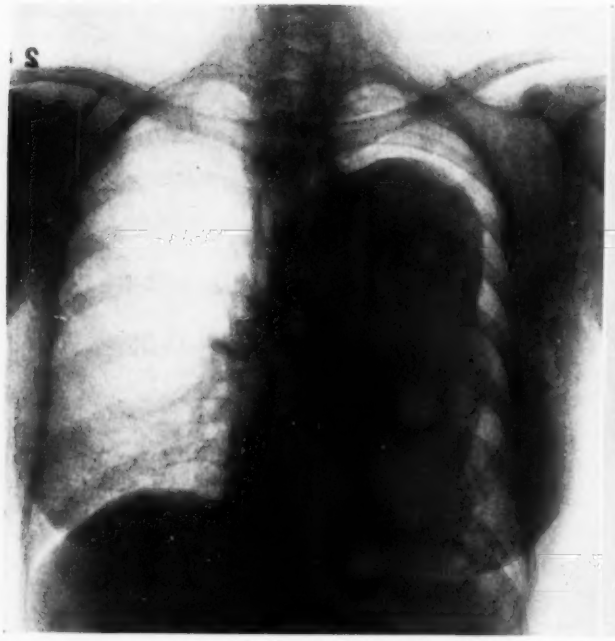

FIG. 13 A. Anterior view. Large sharply defined shadow extending from arch of aorta to left.

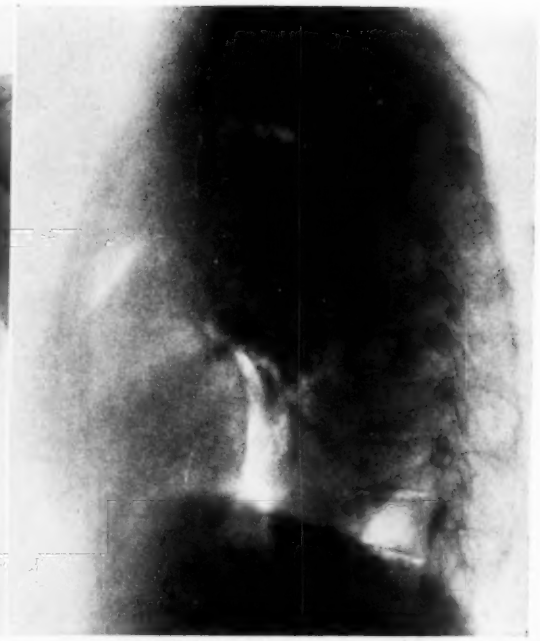

FIG. 13 B. Lateral view. Entire course of thoracic aorta is markedly dilated and is overlapping dorsal vertebrae. Confirmed by postmortem examination.

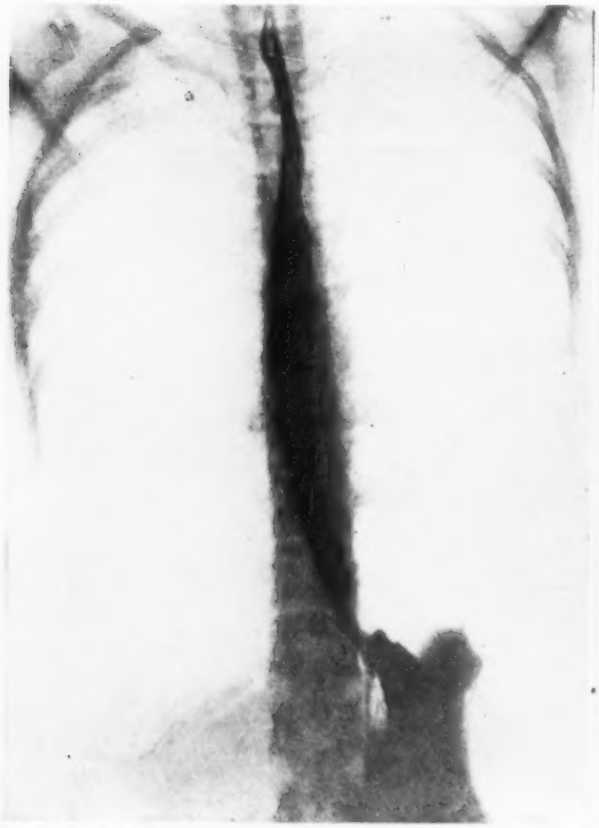

FIG. 14 A. Anterior view. Position of esophagus in front of dorsal spine.

FIG. 14 B. Lateral view. In region of superior mediastinum trachea is in front of esophagus. Below arch of aorta esophagus is in front of descending aorta and behind heart.

FIG. 15. Lateral view. Upper end of esophagus is displaced forward by enlarged gland.

FIG. 16. Lateral view. Compression of esophagus as result of enlarged heart.

FIG. 17. Lateral view. Compression of lower end of esophagus by left ventricular hypertrophy.

FIG. 18. Lateral view. Esophageal distortion as result of diaphragmatic hernia.

FIG. 19. Lateral view. Esophageal perforation into posterior mediastinal structures due to carcinoma.

FIG. 20. Lateral view. Benign esophageal stricture in woman, aged twenty-four. No history of injury. Esophagoscopic examination and subsequent treatment confirmed benign nature of lesion.

FIG. 21. Lateral view. Esophageal stricture at cardiac end of esophagus. Benign in origin. Transparent area is due to plug of food.

FIG. 22. Lateral view. Carcinoma of esophagus below middle third.

density occupying the anterior half of the superior mediastinum. Evidently its origin must be the ascending or anterior portion of the arch. In this case it appears that we are dealing with two aneurysms as shown in the lateral view. One is arising from the ascending portion and the other from the transverse arch. The displacement of the arch downward and backward is shown quite distinctly. Aneurysms may also arise from the concave or inferior aspect of the arch of the aorta. This is again best shown in the lateral view (Figs. 12 A and B). The anterior view shows a slight dilatation of the aorta on the left side beyond the arch. In the lateral view there is shown a bulging arising from the inferior surface of the arch which depresses the anterior wall of the trachea and the left bronchus. This partial obstruction resulted in a bronchiectasis. All the *x*-ray findings were confirmed by postmortem examination. An extreme case of marked dilatation of the aorta is illustrated in Figures 13 A and B. The lateral view shows that dilatation involves the whole of the thoracic aorta. The left bronchus is displaced downward and forward by the marked bulging of the concave surface of the arch.

Behind the trachea and parallel to it is the esophagus (Figs. 14 A and B) which cannot be recognized unless it is rendered visible by an opaque medium. The course of the esophagus from above downward is almost straight. Above, it is continuous with the cervical portion of the esophagus through the superior aperture of the thorax. Throughout its whole course it is in front of the spine with the exception of its lower extremity which deviates toward the left before it passes through the esophageal orifice in the diaphragm. In the region of the superior mediastinum it is in front of the bodies of the dorsal vertebrae. In the region of the posterior mediastinum the esophagus is behind the pericardium and in front of the descending aorta. It is never found to rest against the spine under normal conditions notwithstanding the teachings of several anatomists to the contrary. The esophagus is crossed by the arch of the aorta on the left side. In this region its contour is often found to be depressed by the arch of the aorta.

Fig. 23. Lateral view. Carcinoma of cardiac end of esophagus on posterior wall.

Under abnormal conditions the esophagus may be found to be displaced as shown in Figure 15, where the displacement is forward and is due to enlarged tracheal glands. Depression of the anterior wall of the esophagus as a result of cardiac enlargement is shown in Figure 16. Localized depression by enlargement of the left ventricle is shown in Figure 17. The esophagus is occasionally found to have a zigzag and distorted appearance when associated with a diaphragmatic hernia as shown in Figure 18. Perforation of the esophagus with extravasation of opaque medium into the mediastinal tissues is best illustrated in the lateral view (Fig. 19). This was primarily due to a carcinoma. Cicatricial strictures are also best shown

FIG. 24 A. Diaphragmatic hernia through esophageal orifice.

FIG. 24 B. Esophageal diverticulum of lower end of esophagus.

FIG. 25. Lateral view. Small diverticulum of cardiac end of esophagus.

FIG. 26. Anterior view. Cardiospasm. Fundus of stomach is normal.

FIG. 27. Anterior view. Malignant tumor of stomach encroaching upon cardiac end of stomach, thus producing obstruction of esophagus. Appearance closely resembles simple spasm.

FIG. 28. Anterior view. Deviation of cardiac end of esophagus to left as result of malignant growth. Confirmed by operation.

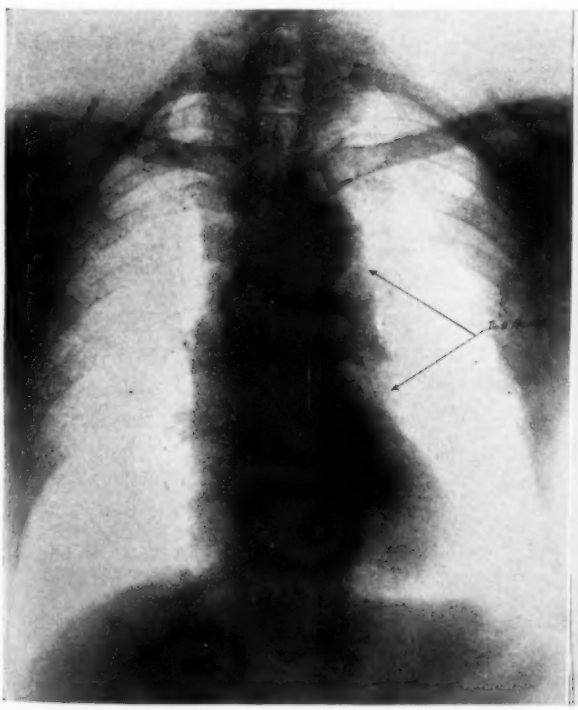

FIG. 29 A. Anterior view. Displacement of descending aorta to left due to dilatation.

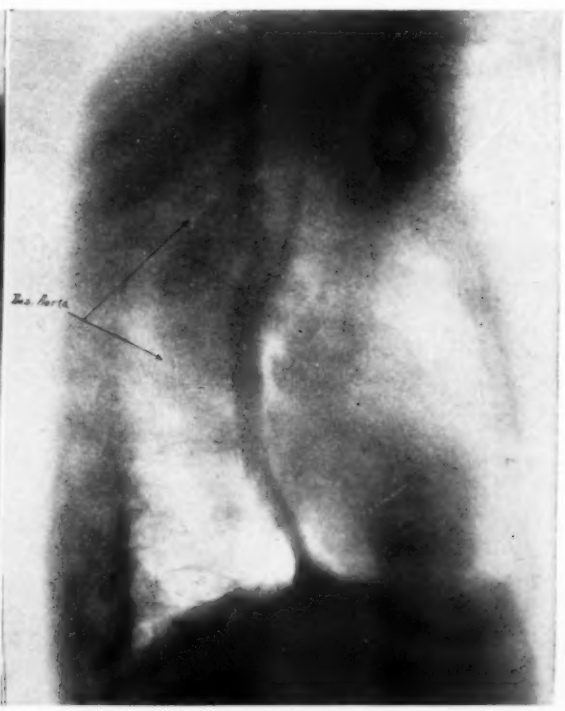

FIG. 29 B. Lateral view. Aorta is seen to overlap dorsal vertebrae.

in the lateral view. Figure 20 shows a stricture in the middle of the esophagus. Figure 21 shows a stricture at the cardiac

Fig. 30. Anterior view. Displacement of lower end of esophagus to left due to aneurysm of descending aorta.

end of the esophagus due to a caustic burn. Evidently the clear space between the opaque medium and cardiac end is due to ingested food which failed to pass the narrow opening of the stricture. Malignant strictures or deformities in the contour of the esophagus can also be demonstrated in the lateral view to their greatest advantage. Figure 22 shows deformity of the esophagus below its upper half. Figure 23 shows a deformity of the posterior wall of the esophagus at the cardiac end. Diverticuli of the lower end of the esophagus can readily be demonstrated in the antero-posterior or lateral views. The differentiation between a diverticulum of the lower end of the esophagus and a diaphragmatic hernia through the esophageal orifice is often difficult to make. A careful study of the several characteristics associated with diverticula and diaphragmatic hernia has helped us in arriving to a correct diagnosis. Diaphragmatic hernia (Fig. 24 A) through the esophageal orifice presents the following differential points:

1. The part of the stomach above the diaphragm consists of the fundus and cardiac end of the stomach.
2. The expansion of the hernial sac is equally distributed on both sides of the spine.
3. The size of the hernia varies with the position of the patient. It is larger in the prone and smaller in the erect position.
4. The fundus is absent in the left hypochondriac region.
5. The stomach below the diaphragm is small.

Esophageal diverticulum of the lower end of the esophagus (Fig. 24 B) presents the following points:

1. The sac arises and communicates with the esophagus.
2. The sac is found to be located to one side of the spine.
3. The size of the sac remains the same in any position.
4. The fundus of the stomach is found in the region of the left hypochondrium.
5. The stomach is of normal size and shape.

Figure 25 shows a small diverticulum which was best shown in the lateral view. Cardiospasm of the esophagus should always include, if possible, an examination of the stomach in order to exclude a lesion of this organ. In the demonstrations of cardiospasm there is no special advantage in taking a lateral view. An anterior view (Fig. 26) will show the existing condition without any difficulty. Figure 27 to all appearances resembles a typical case of cardiospasm. However, a study of the stomach will show that the lumen is encroached upon by a mass which extends toward the cardiac end producing an organic obstruction. The position of the cardiac end of the stomach should always be watched. Any marked deviation from

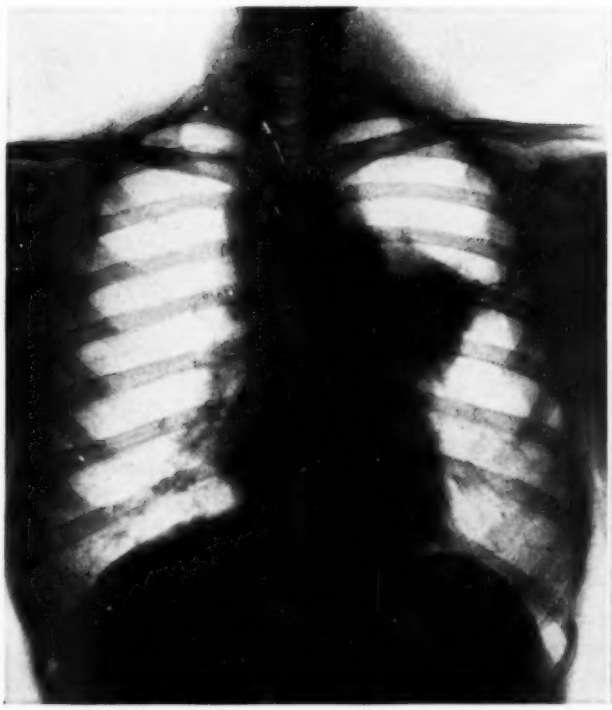

FIG. 31 A. Anterior view. Dense shadow on left side of heart in case of Hodgkin's disease. Confirmed by biopsy.

FIG. 31 B. Lateral view. Anterior and posterior mediastinal glands are enlarged.

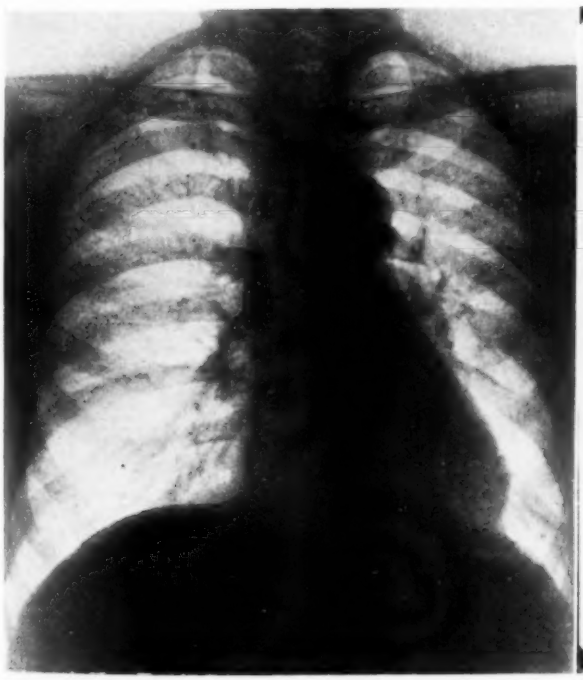

FIG. 32 A. Anterior view. Heart is displaced to left and superimposed upon heart shadow is another shadow presumed to be aorta.

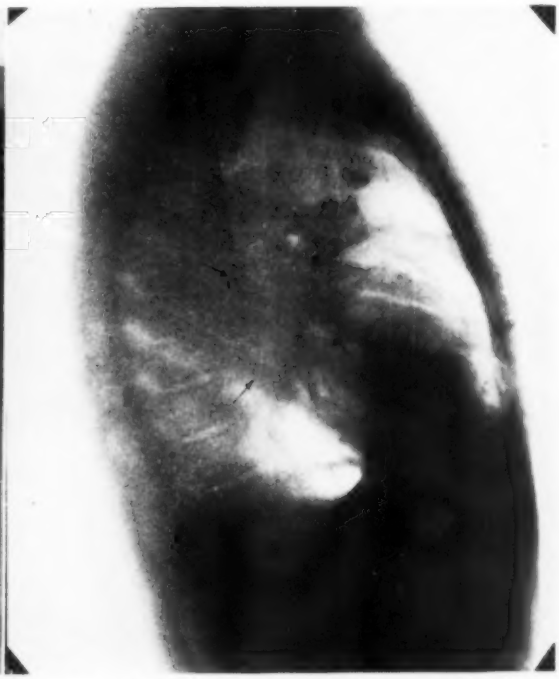

FIG. 32 B. Lateral view. Region below arch of aorta is obscured by dense shadow. Diagnosis of tumor of posterior mediastinum was confirmed by postmortem examination.

FIG. 33 A. Lateral view. Ovoid transparent area is seen to be located between heart and aorta.

FIG. 33 B. Lateral view. After barium injection transparent shadow proved to be due to diaphragmatic hernia.

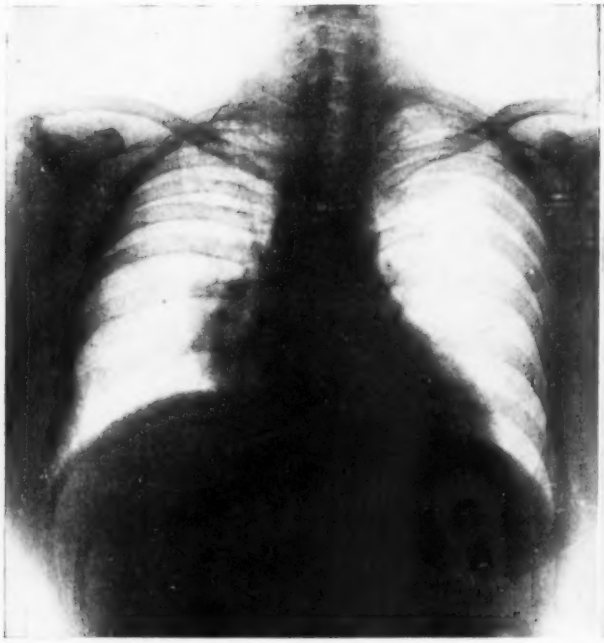

FIG. 34 A. Anterior view. Dense shadow on right side of heart.

FIG. 34 B. Lateral view. Spinal tuberculosis with abscess extending into posterior mediastinum.

the normal should lead one to suspect the possibility of an organic lesion (Fig. 28). The *x*-ray diagnosis of carcinoma of the esophagus was confirmed by operation in this case.

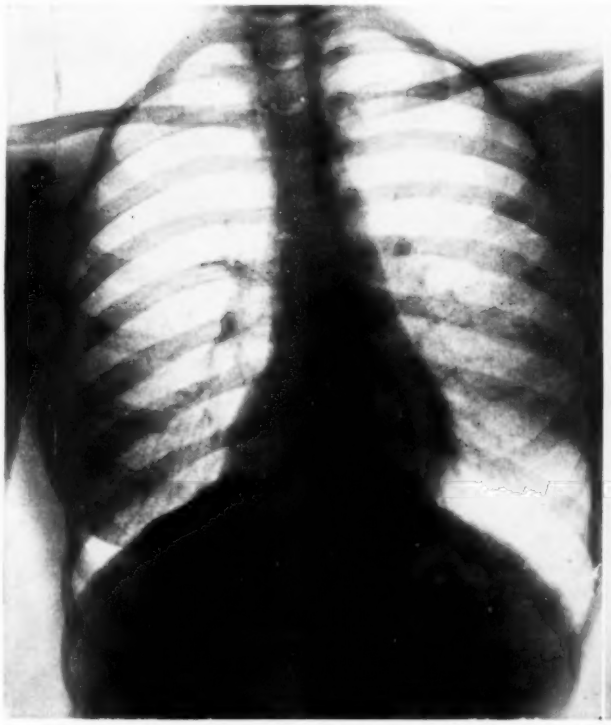

Fig. 35 A. Anterior view. Dense shadow on right side of heart.

Fig. 35 B. Lateral view. Tuberculous abscess originating from spine.

The descending aorta is located in front of the spine. Under normal conditions but very little of it is seen in the anteroposterior view. Whenever the aorta is observed in the anteroposterior view it is either dilated or dislocated. In the lateral view its whole course can readily be seen in most individuals. Above, it is continuous with the arch of the aorta. Below, it is lost from view below the diaphragm. In its downward course is follows the dorsal spine very closely. A deviation in the course of the spine will reflect upon the course of the aorta. Whenever the aorta is found to overlap the bodies of the dorsal vertebrae in a true lateral view it is either displaced or dilated. Deviation of the aorta usually takes place to the left side, since this is the point of least resistance. On the right side the firm structure of the traches more or less prevents displacement to this side. Figure 29 A shows marked displacement of the descending aorta to the left. Figure 29 B shows the lateral view with the descending aorta overlapping the entire dorsal spine. An aneurysm arising from the descending aorta is best demonstrated with an opaque medium in the esophagus. The displacement of the lower end of the esophagus to the left in Figure 30 was due to an aneurysm.

Demonstration of enlarged glands or tumors in the posterior mediastinum is greatly assisted by lateral views. Figures 31 A and B show a case of Hodgkin's disease. Figures 32 A and B show a case of lymphosarcoma. Postmortem examination confirmed the *x*-ray findings. A rather unusual transparent shadow located between the posterior surface of the pericardium and the descending aorta (Figs. 33 A, B) proved to be due to a diaphragmatic hernia. It is needless to say that the anterior view failed to show anything abnormal. Occasionally abnormal shadows

in the neighborhood of the posterior mediastinum cannot be explained unless a study of the thorax is made in the lateral position. Figures 34 A and B and Figures 35 A and B show the exact nature of the shadows to be due to tuberculous spinal abscesses and that they are only encroaching upon the mediastinum, not originating from it.

CONCLUSIONS

1. A study of the superior and posterior mediastinum should include both an anteroposterior and lateral views.

2. The advantages of the lateral view over the anteroposterior view are shown by many illustrations.

3. The lateral view enables one to determine the position of the trachea in relation to the thoracic walls. Any deviation from its normal course and the probable cause can be determined with a high degree of accuracy.

4. The origin of aneurysms can be accurately determined by studying the location of the aneurysm in relation to the trachea.

5. Lesions affecting the esophagus can be studied with greater advantage in the lateral view.

6. Abnormal changes in the descending aorta are best recognized in the lateral view.

7. The exact origin of abnormal shadows encroaching upon the mediastina can be determined in the lateral view.

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* Continued from p. 492.

ANESTHESIA FOR THE CARDIAC AND ASTHENIC PATIENT

PRELIMINARY REPORT OF THE ACTION OF SODIUM AMYTAL ON THE DISEASED HUMAN HEART*

J. O. Bower, M.D., J. C. Burns, M.D., and H. A. K. Mengle, M.D.

PHILADELPHIA

SODIUM amytal administered intravenously or rectally in correct dosage reduces the tonicity of the voluntary muscles only slightly while the peripheral circulation is maintained, thereby reducing the possibility of shock to a minimum. Because of this lessened liability to shock the anesthetic is especially indicated for the weak and asthenic patient.

The following charts show the effect of sodium amytal on the cardiovascular system of 32 patients suffering with myocarditis. The degree of myocardial degeneration was determined by physical examinations and repeated electrocardiographic observations. The anesthetic was given forty-four times. The same number of observations were made in patients with normal cardiovascular systems for comparison.

CARDIOVASCULAR PATIENTS

No. of patients—31
No. of anesthesias—44—Deaths 0
Operations abnormal cardiovascular—Major 69 per cent—Minor 31 per cent
Average age—61.4 years

Myocarditis	No. of Patients	Age	Age Distribution
Mild	3	20–30	2
		30–40	1
Moderate	6	40–50	2
		50–60	8
Severe	15	60–70	12
		70–80	3
Serious	7	80–90	3

CARDIOVASCULAR CHANGES

	Myocarditis	Normal Cardiovascular
Average pulse pressure	71	44
Average systolic pressure	151	119
Average diastolic pressure	81	75

	Systolic Per Cent	Diastolic Per Cent
Average drop in blood pressure intravenous	40(26)	16(20)
Average drop in blood pressure rectal	27(12)	15(18.5)
Average drop in blood pressure intramuscular	12(8)	4(5)
Average drop in blood pressure intravenous	20(20)	8(6.6)
Average drop in blood pressure rectal	8(10)	4(3.3)
Average drop in blood pressure intramuscular	.....	.....
Average drop in blood pressure supplement	.....	.....

Pulse Rate	Myocarditis	Normal Hearts
Drop	20 per cent	16 per cent
Rise	80 per cent	34 per cent
Rise—intravenous	16 beats	22
Rise—rectal	8 beats	.....

Cases of recent apoplexy showing advanced arteriosclerosis, angina pectoris, auricular fibrillation and decompensation are included in this group. While the average pulse pressure in the myocardial group was 71 there were several patients in whom it was impossible to obtain a diastolic pressure, which would increase the actual average pulse pressure. While the comparative drop in systolic pressure in the two groups is slight (6 per cent) note that the drop in the diastolic pressure in the myocardial group is three times greater than that of the normal group; this is true for both the intravenous and rectal method of administration. As would be expected there are more than twice the number of patients showing an increase in pulse rate in the myocardial over that of the normal group. The surprising observation is that the intravenous administration did not increase the pulse rate in the myocardial over that of the normal group. In both normal and myocardial groups the rectal method of administration as advocated by Dr. Ravdin[1] produced the slightest circulatory change.

Sodium amytal supposedly produces narcosis by entering into solution with the fat-like constituents of lipoid tissue.

[1] Ravdin, I. S. *Am. J. M. Sc.*, 178: 379, 1929.

* From the Department of Surgical Research, Temple University, and the Philadelphia General Hospital. Submitted for publication June 23, 1930.

The action of the drug on the human brain is similar to its action on the brain of the dog, except that the human brain

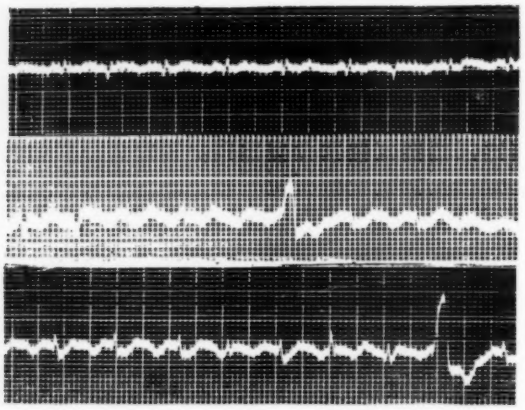

Fig. 1. Auricular flutter with frequent ventricular extra systoles. In addition, ventricular waves are of low amplitude.

is a little more susceptible, requiring less to produce profound sleep. This may be due to the fact that our psychic centers are more highly developed. Sodium amytal abolishes will and intelligence but it does not completely isolate the patient from his surroundings. He is still capable of

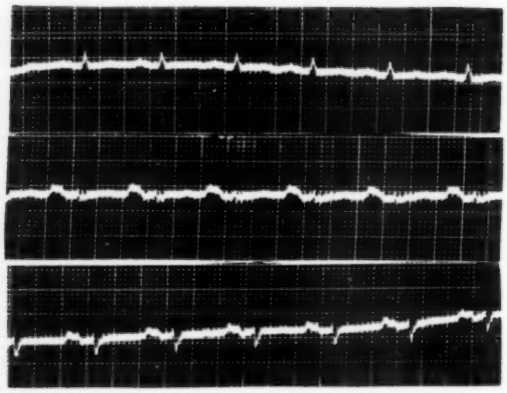

Fig. 2. Tracing shows normal sinus mechanism. P. Waves notched and big and probably can be taken as evidence of disease of auricular muscle. Otherwise, change in mechanism reveals no new evidence. Ventricular waves all of low amplitude.

responding to external stimuli, is restless and is apparently conscious, answers questions at times but *he does not remember*. The pupils are slightly contracted, the gag and skin reflexes are usually maintained, the patellar reflexes are lost. The lips are slightly cyanosed and by contrast increase the associated pallor of the skin.

The effect of the drug on the respiratory system varies with the method of administration. If given intravenously at the rate of 1 c.c. per minute, the patient

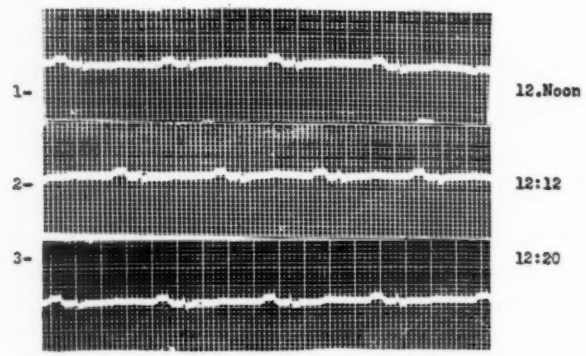

Fig. 3. 1, Injection of sciatic nerve.
2, Division of sciatic nerve.
3, After division of sciatic nerve.

almost invariably yawns at the end of three and one-half to four minutes. Within a moment or two he falls into a peaceful sleep and will continue to sleep unless disturbed. If given rectally, yawning occurs usually at the end of fifteen minutes and he is sound asleep in from thirty to forty minutes. Apparently this preliminary yawn is significant of changes in the

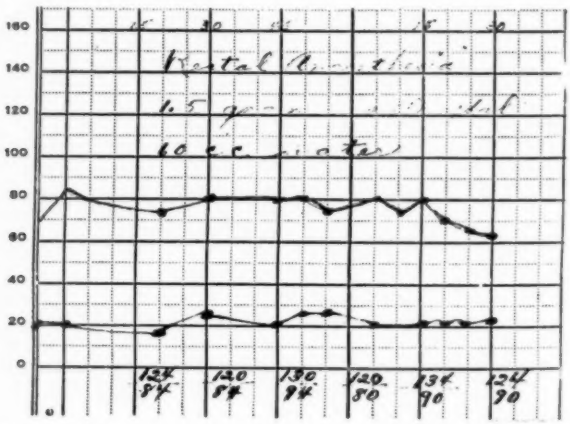

Fig. 4. Rectal anesthesia. 1.5 gm. amytal. 60 c.c. water.

cranial cavity similar to that which takes place directly before and during sleep. We reviewed the literature but were unable to find an explanation of the cause of the yawn. We found that the cerebrospinal pressure is reduced at times as much as 50 per cent, frequently 20 to 30 per cent, precisely at the time the patient yawns. We have kept the needle in the spinal canal as long as fifteen minutes; during this time there was

approximately a 20 per cent rise above the maximum of 50 per cent drop. This is at variance with the findings of Stevenson[1] and his co-workers who studied the intracranial pressure in individuals with hernia cerebri during normal sleep and found an increase in intracranial pressure. The pressure gradually rose until the patient was sound asleep when the curve reached its maximum; this was maintained at a fairly constant level.

We believe the yawn is clinical evidence that the rate of injection of the drug is correct as we have observed that when given too rapidly the patient goes to sleep without it. Untoward symptoms are likely to develop under such circumstances as shown by the following: Our first injection was in an arteriosclerotic male aged sixty-four, in whom a diagnosis of carcinoma of the stomach was made. We were scrubbing when I turned to the resident physician and said, "Will you give the patient the sodium amytal?" He left me and returned in a few minutes and said, "That's the funniest experience I ever had, that man went to sleep in exactly thirty seconds, I timed him." On examination we found that his respirations were disturbed and we deferred the operation. He slept for about eighteen hours. We operated a few days later using a smaller dose of sodium amytal, combined with novocaine. We were unable to obtain a diastolic pressure in this patient at any time.

While the preceding illustrates the effect of the drug on the respiratory center and its safety even in advanced arteriosclerotic disease with myocardial degeneration the following case shows its value in the pathology of the intrinsic cardiac nervous mechanism and in coronary disease associated with advanced myocarditis.

A. male, aged sixty-four was admitted to the Philadelphia General Hospital with symptoms of acute cardiac distress, dyspnea, cyanosis, marked distention of the superficial veins, puffiness of the face, cough and pretibial edema. Examination showed diffuse pulsations over the precordium and epigastrium but no definite rhythm. The pulse was irregular and rapid, the systolic blood pressure 110; diastolic could not be obtained. A diagnosis of auricular fibrillation with myocardial degeneration was made. This was confirmed by the electrocardiograph (Fig. 1). The patient was digitalized and rhythm became normal (Fig. 2). Fourteen days after admission he developed gangrene of the right leg, lower third; twenty-one days after admission an amputation was done at the lower third of the thigh, sodium amytal being used, rectal administration and procaine, local infiltration. The electrocardiograph was connected to the patient during the operation. The accompanying charts show the electrocardiographic tracings (Fig. 3), changes in pulse, blood pressure, and respiration throughout the operation (Fig. 4). He made an uneventful operative recovery.

In another male aged fifty-six who had a primary carcinoma of the lung associated with myocarditis and angina pectoris, sodium amytal was administered four times with no ill effects; directly prior to the second operation he developed an attack of angina which was not relieved by a hypodermic of ½ grain of morphine sulphate but was relieved by an intravenous injection of 3 c.c. of a 10 per cent solution of sodium amytal; he fell asleep at the end of three minutes and slept for eighteen hours.

While only 22.5 per cent of this series of cardiac patients were as seriously affected as the three previously mentioned, our observations of the effect of sodium amytal on these and the others less seriously affected, warrants our advocating its use in such cases alone or in combination with local or block anesthesia.

CONCLUSIONS

1. Sodium amytal has little direct effect on the diseased heart muscle.

2. The slight circulatory changes associated with the administration of the drug are due to (1) and to the maintenance of tone in the voluntary muscles and the peripheral circulation.

3. The initial effect of the drug on the central nervous system is associated with a change in cerebrospinal pressure.

4. Because of the drop in cerebrospinal pressure sodium amytal should not be given as a preliminary to spinal anesthesia unless allowance is made for the increase in diffusibility.

[1] Stevenson, L. *Am. J. M. Sc.*, 178: 663, 1929.

SURGICAL TREATMENT OF CHRONIC EMPYEMA*

DANIEL H. BESSESEN, M.D.

MINNEAPOLIS, MINN.

ANYONE who makes a critical study of the subject of empyema, acute or chronic, will be faced with the limited understanding or experience which is expressed by statements concerning the proper infrequency of chronic empyema or the good prognosis which should accompany the treatment of chronic empyema. Neither of these statements is correct. The frequency of chronic empyema will vary from year to year under the influence of business conditions affecting general health and hygiene; will vary according to the type of bacterial infection which is causative of the primary lesion, the streptococcus and mixed infection producing the largest number of chronic cases; finally, the type of complications which are encountered in the pathologic picture.

It is an absolute essential that the nature of acute empyema be understood. Since the chronic form of empyema will not occur until an acute case has had its run, many acute empyemata will become chronic under the misunderstanding of its serious nature. It is this fact which has led to most of the statements that there should be no chronic empyema. If one pursues a faulty course in the acute disease, the chronic suppuration will inevitably occur.

Acute empyema is a grave disease. It is not sufficiently realized that mixtures of infections will lead to chronicity. Other factors favoring chronicity are those which allow any cavity to remain in the pleura, between the lung and the chest wall. Inserting a tube, even a small one, will permit a tiny pocket to form around this tube, which will not empty, even after the tube is withdrawn. Localization of pus in places awkward to insert drainage will lead to long-standing suppuration. Such places are between the lobes of the lung and between the lung and the mediastinum; more rarely between the lung and diaphragm. Rupture of the lung, with bronchopleural fistula, allows an artificial pneumothorax, mixture of infection, and inability to expand the lung, or collapses the chest wall without considerable and extensive surgical procedures. Finally, the most severe of all forms of chronic empyema will be produced by lung abscess which may or may not have ruptured through into the pleura.

The formation of a pocket of pus of long standing will eventually lead to thickening of the pocket, and cicatrization of the fistulous tract leading from the bronchi to the pleura. To hope to remove this scarring, even with the softening influence of Dakin's solution, is almost impossible. Especially is this the case in the presence of a fistulous tract, where Dakin's solution gains entrance into the trachea and pharynx. The irritating action of the chlorine stimulates coughing, with spasmodic respiration, and leads to greater filling of the pocket with air and extension of infection. To expect to cure all cases of acute empyema without encountering some of these complications which lead to chronic empyema is expecting the miraculous. It follows therefore that in a certain percentage of cases of acute empyema, chronicity will result. In like manner, when one deals with the severe forms of complicated lung suppuration which associate themselves with or cause chronic empyema, the prognosis is indeed grave.

The error of the former open method of treating infections of the pleural cavity lay in the mixing of infections early in its course. Such a mistake will constitute positive assurance of chronic empyema. Many cases of acute empyema will be healed by aspiration through a fair sized

* Submitted for publication June 23, 1930.

needle, repeating the drainage at intervals of several days depending upon the amount of suppuration. The existence of pleural exudation should be recognized early, but approached with greater leisure. Milder bacterial forms of infection may be dealt with earlier; the more virulent orders should be permitted longer time to collect before removal of the fluid. At approximately the interval of change from clear fluid into cloudy is the optimum time for initial drainage. From this time on the reduction of bacterial content of the suppuration fluid is indicative of improvement as is also the decreasing temperature of the patient.

Where these factors are not present, some complicating element in the progress of the patient is indicated and search must be made diligently until a correct analysis of the situation is completed.

Under ordinary circumstances, where no communication exists from the pleura to the respiratory tract, the use of Dakin's solution will dissolve out all fibrous tissue and allow expansion of the lung, at the same time assuring adhesions of the lung to the chest wall as the expansion takes place. No more of the fluid than the cavity will hold should be injected at any one time, or the adhesions already formed will be broken down again. Formation of adhesions irregularly, leaving small pockets of pus bedded around with adhesions, does not leave the patient well. The illness will continue, sometimes penetrating into the lung tissue or breaking down the pockets existing into one large pus sac. With the chlorine solution as an antiseptic, the tiny pocket made by a tube in the pleura is not usually formative of residual suppurative material. With other forms of antiseptics, however, a small pus pocket may remain. Mansur has recently reported a splendid simple constant vacuum aspiration tube, the Wilson tube, which may be placed through the chest wall in acute empyema. It has a flat disc surface on the interior and exterior of the chest wall with a flap over its outer opening. Its insertion cannot leave any space within the pleural cavity which is not filled by lung tissue. It does not leave the protruding tip of a tube to prod the lung, form a small pocket, or penetrate into the respiratory passages. This is the simplest and safest device as yet produced for the purpose of drainage of the empyema cavity.

This cannot be used however on patients with interlobar collections of pus, or between the lung and mediastinum, or even at the diaphragm. In the common customary pus pocket collecting between the chest wall and the lung, the optimum point of drainage is in the sixth intercostal space in the posterior axillary line, since with the patient resting in bed, this is the dependent point of the barrel-shaped thorax. In the cases of interlobar suppuration, a tube may be passed into the pus cavity, which will gradually be withdrawn as the infection subsides. This type of pathology is most likely to form bronchopleural fistulas, so great care is needed in the handling. Roughness on inserting the tube may puncture the friable infected lung tissue. This is true at the periphery of the lung as well as at the more central portion of the fissures. It is the penetration of lung which may lead to abscess formation also, though more commonly the etiology of abscess in the lung is pneumonia. The filling of the lung with pneumonic change decreases the blood supply. Sufficient filling of the alveoli with necrotic material will completely shut off the blood vessels, which under pressure and in the presence of septic material allows decay and necrosis of the alveolar walls. When the pneumonia passes off, the breaking down of the necrotic tissue leaves an abscess pocket. This, in the presence of empyema will frequently produce a vicious circle, each lesion stimulating the persistence of the other and preventing its proper response to treatment.

The treatment of uncomplicated chronic empyema is the same as the acute; empty-

ing and sterilizing the cavity, and allowing complete collapse of the sac by expansion of the lung substance. This can be accomplished fairly readily where there is no communication between the pleura and respiratory passages, or abscess formation. Careful *x*-ray work with roentgen plates and fluoroscopic study will inform the surgeon of the exact condition present. The treatment depends entirely upon a clear-cut comprehension of the pathology. The outlook to the patient is extremely grave at best, and only a most painstaking analysis of the problem will give the satisfaction of good health to both the patient and the attendants.

In cases of bronchopleural fistula or lung abscess healing cannot occur without some form of surgical interference, usually of extensive nature. The best operation for bronchopleural fistula is the paravertebral thoracoplasty, the extensiveness of the dissection depending upon the size of the suppurating cavity. The aim or purpose of the operation is to collapse the chest wall against the lung, thus closing the exudative pocket. The pressure of the chest wall usually closes the fistulous tract and relieves the pleura of air entry. The former custom of removing the bony structure from immediately over the suppuration is not dependable because the chest will not collapse from the curvature of the ribs to the vertebral column. The rib structures attached to the laminae will become elevated instead of falling. The chest tends to flatten anteroposteriorly, but the added advantage of lateral collapse is lacking. Both the anteroposterior and lateral depression are obtained by the paravertebral thoracoplasty, so this is the operation of choice. In some instances, the removal of the intercostal muscles and the ribs, as devised by Schede of Hamburg, may be the selected operation, though this carries with it a higher mortality than any other. It is more likely to be chosen in case of abscess of the lung in combination with empyema.

Some lung abscesses respond to milder forms of treatment as postural, or pneumothorax together with bronchoscopic drainage. The presence of fluid in the pleura accomplishes the pneumothorax, and if, as so often happens, bronchopleural fistula is also established, there is present a source of suppuration which, as shown, calls for more elaborate and more dangerous forms of surgical attack. Lilienthal has had splendid success in making a collapse of the chest wall and sinking the integumental flap into the widely opened abscess of the lung, allowing free granulation to help close the cavity. The removal of a portion of the lung for abscess in the presence of empyema is ill advised as a primary procedure, as lobectomy at best carries such great risk. Some less radical operation is best tried first.

Chronic empyema is a necessary evil, not easy to overcome when accompanied by such variants as peculiar placement of pus pockets, bronchopleural fistula, or lung abscess. Uncomplicated chronic empyema will readily respond to drainage, sterilizing and collapse of the cavity. Complicated empyemata are not to be considered in the same category and will require elaborate, dangerous methods of surgical approach, the selection of which will be determined only by careful study of the pathology present and the needs of the patient.

THE DANGER OF THE PROLONGED USE OF LUGOL'S SOLUTION

IN THE TREATMENT OF EXOPHTHALMIC GOITER WITH CASE REPORTS AND A STUDY OF THE PATHOLOGY*

ARNOLD S. JACKSON, M.D., AND GEORGE H. EWELL, M.D.

MADISON, WIS.

A NUMBER of very critical conditions and deaths have recently resulted from the misuse of iodine in the treatment of exophthalmic goiter. Although several physicians have called attention to this danger, we have not noted a report of any series of cases showing the harmful effects of the promiscuous use of iodine therapy. We have observed occasional "iodine fast" cases of exophthalmic goiter for several years, but the number has increased so markedly during the past year that the seriousness of this evil is apparent. We believe it is time for those who are administering iodine so freely to these patients, to know the facts and the end-results of this type of treatment.

In 1924 one of us (A. S. J.) called attention to the danger of giving iodine promiscuously to persons with adenomatous goiter and suggested the term "iodine hyperthyroidism" for this syndrome. In a short time more than 50 cases, including 3 patients who died, were examined. We feel that this warning with regard to the misdirected form of therapy may have accounted for the steady decrease in the number of cases which are now seen.

Only a few years ago physicians gave iodine freely without regard for the kind of goiter, unless it was of the exophthalmic type. All medical schools and textbooks warned against using iodine for this condition. Perhaps some of this apprehension was due to Kocher, who called attention in 1895 to the danger of iodine in the treatment of goiter and suggested the term Jod Basedow's disease for the toxic condition which resulted from its use. This condition, however, is not Basedow's disease or exophthalmic goiter, as it is commonly known, but iodine hyperthyroidism, a toxic condition produced in a previously non-toxic adenomatous goiter by the use of iodine. As a result of the wide dissemination of Kocher's theories a great fear of using iodine developed, particularly of using it in Basedow's disease.

In 1912 Marine showed that iodine caused a marked reversion of the hyperplastic to the colloid state in exophthalmic goiter; but it was not until 1923 that Plummer proved beyond a doubt that a remarkable clinical improvement resulted from the use of iodine in this disease.

Too often in medical literature supposed facts are handed down from generation to generation without the author's even attempting to verify the conclusions or to ascertain the source from which they were drawn. Another example of the fallacy of these hackneyed ideas is that concerning the use of meats, particularly red meats in this disease. No one has ever proved meat to be harmful in Basedow's disease any more than in hypertension. Yet, in the standard textbook on goiter between the period 1900 to 1922, one finds, "when the disease has got a firm hold on the patient, if he continues to eat freely of red meats such as beef, veal, mutton, or pork, nothing becomes plainer than the futility of drugs and especially those directed against mere symptoms."

We now know that such statements are inaccurate and yet they are still being quoted and taught. When Plummer showed that iodine had a remarkably beneficial effect on patients with exophthalmic goiter his conclusions were received with considerable doubt, because the adverse opinion had been accepted for so many years. Gradually, however, reports of series of

* Submitted for publication August 14, 1930.

cases from various parts of the country appeared to verify his statement. He early called attention to the fact that Lugol's solution did not effect a cure, but was of great benefit when used in preparing the patient for operation, or in bringing a patient through a crisis.

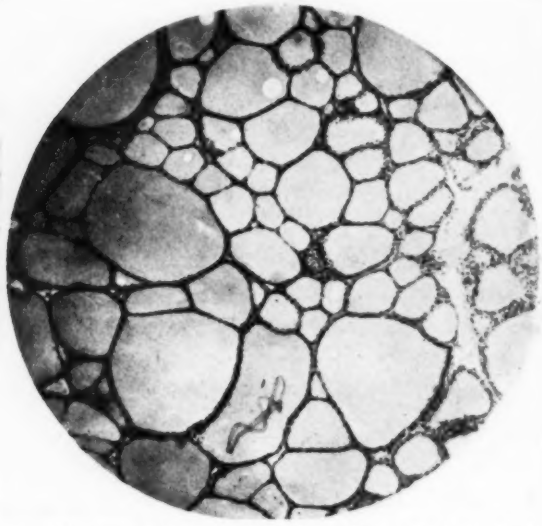

Fig. 1. (Case 57.) Exophthalmic goiter. Patient had been on iodine continuously for more than two years and had taken one dram of Lugol's solution daily for one year prior to operation. (×12.)

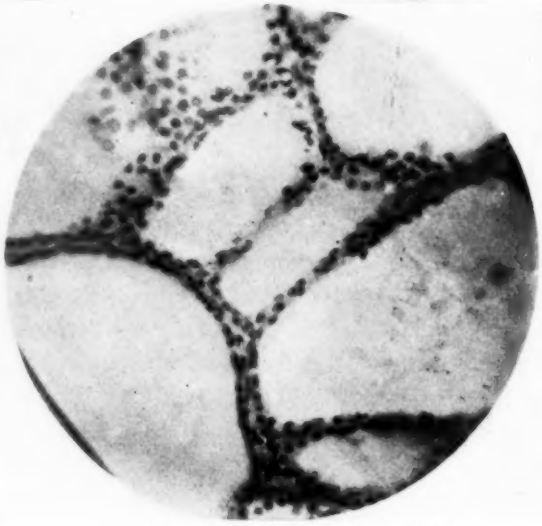

Fig. 2. Same as Fig. 1. (×62.)

At first Lugol's solution was administered cautiously in small amounts, and for only short periods of time. Later, when the remarkable effect was observed and patients were saved in a spectacular manner from crises and restored to a state of well-being in a few weeks' time, physicians threw caution aside and gave iodine freely.

After taking iodine, the bedridden patient was not only able to be up and about in a few days, but he gradually gained weight, the heart and tremor quieted down, his strength as well as his normal disposition returned, the stare disappeared, and he seemed benefitted in every way.

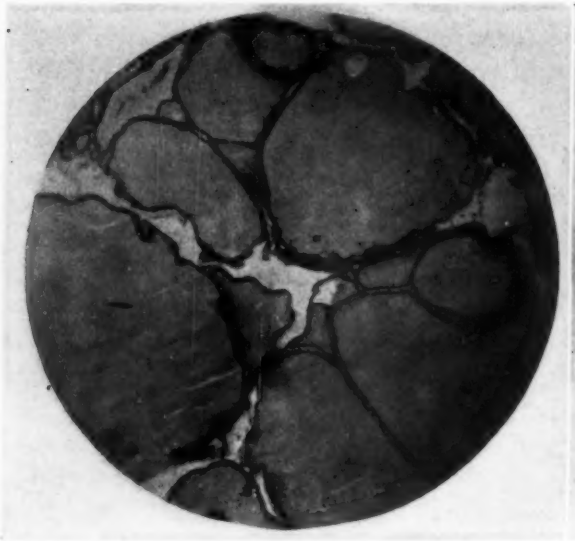

Fig. 3. (Case 52.) Iodine continuously for more than two years. (×12.)

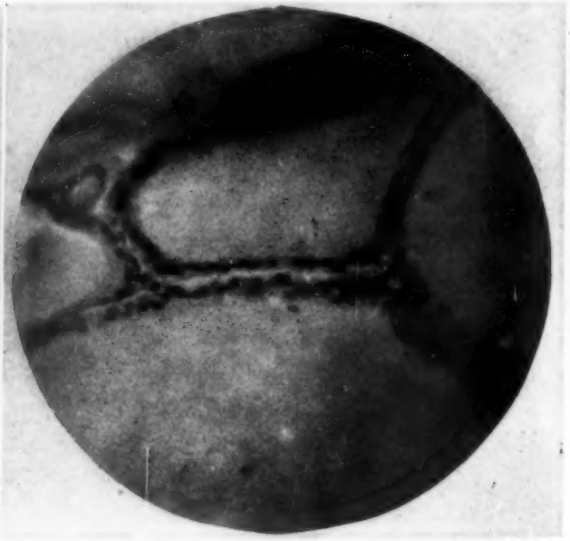

Fig. 4. Same as Fig. 3. (×62.)

This improvement continued for weeks and even months. The metabolic rate frequently returned to normal, or at least dropped considerably. The patient was often able to resume his duties. In the meantime a note of warning was sounded by those who were seeing their first "iodine fast" cases.

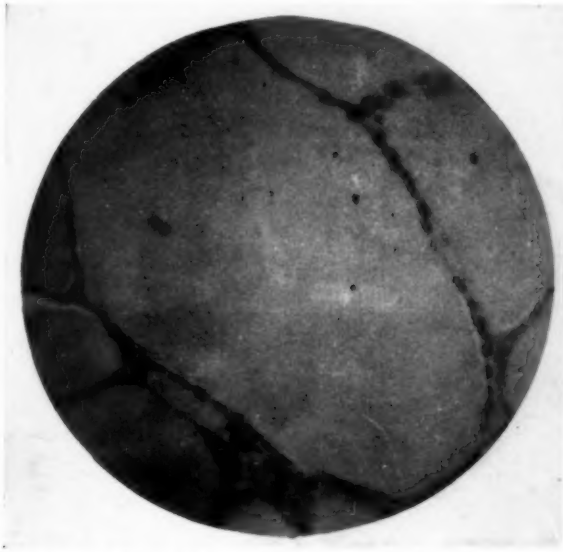

Fig. 5. (Case 53.) Iodine for six months. (×62.)

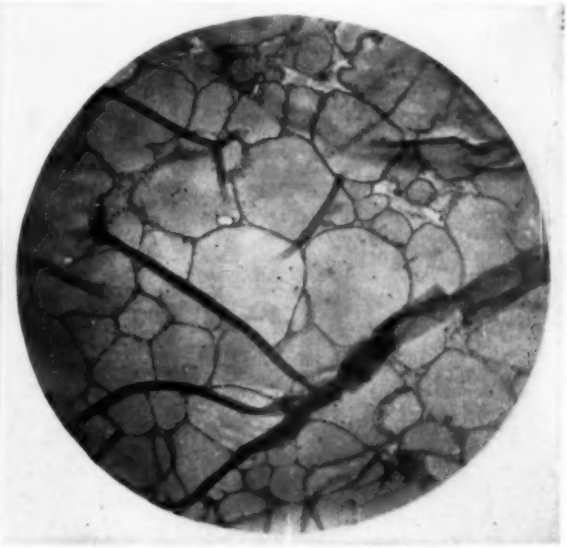

Fig. 6. Same as Fig. 5. (×12.)

Fig. 7. (Case 54.) Iodine for six months. (×62.)

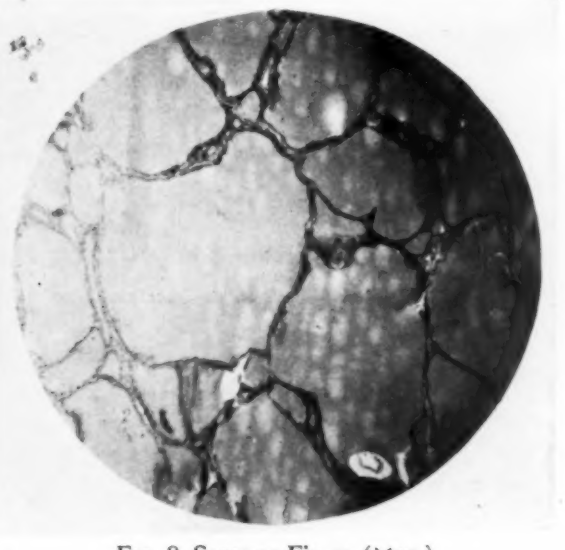

Fig. 8. Same as Fig. 7. (×12.)

At the meeting of the American Society for the Study of Goiter in 1928, one of us (A. S. J.) called attention to the fact that although iodine effected a temporary benefit in exophthalmic goiter, this was followed by a period in which the patient became "iodine fast" and developed a tolerance to the drug. The metabolic rate again became elevated and the myocardium was so damaged that auricular fibrillation often occurred. In the meantime the patient had improved, to all outward appearances, and had often gained 30 or 40 pounds.

The period of improvement is variable. Some patients respond very well for three

or four weeks, and then, in spite of rest and continued large amounts of iodine, it is impossible to bring them back to their former state of health. Eventually these patients seek the surgeon's help, and he must face a grave responsibility. The risk of operation is frequently as great as in the days before Lugol's solution was used. For years primary thyroidectomies have been done in all cases of exophthalmic goiter at our Clinic, but we feel that this procedure is not a safe one for the patient who has become "iodine fast."

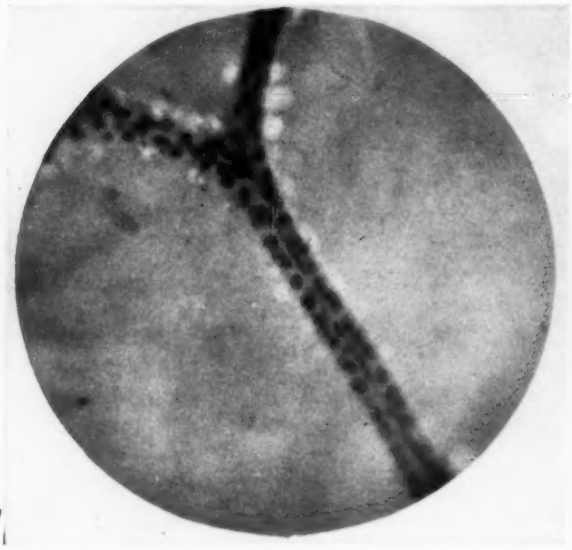

Fig. 9. (Case 55.) Iodine for two months. (×62.)

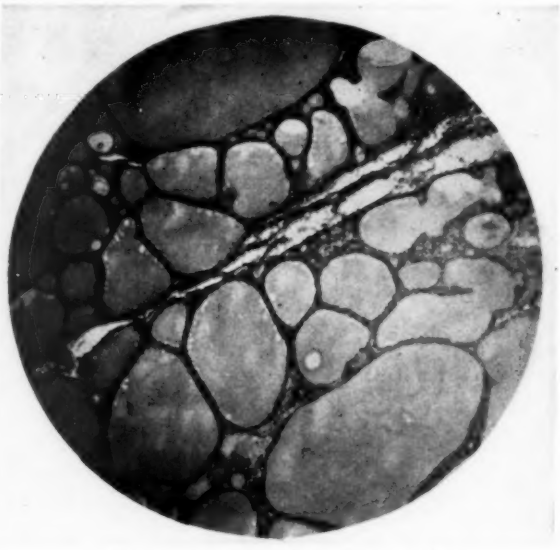

Fig. 10. Same as Fig. 9. (×12.)

The unfortunate outcome of two such operations in patients who were in this condition, having received Lugol's solution for several months before coming to us, has proved to our satisfaction that lobectomy or even ligation is the operation of choice. However, I have not found it necessary to delay the second stage of the operation more than a week or ten days, because in most instances the metabolic rate has dropped to 25 or lower which, in the absence of any other complications, is a safe rate at which to complete the operation in this kind of goiter.

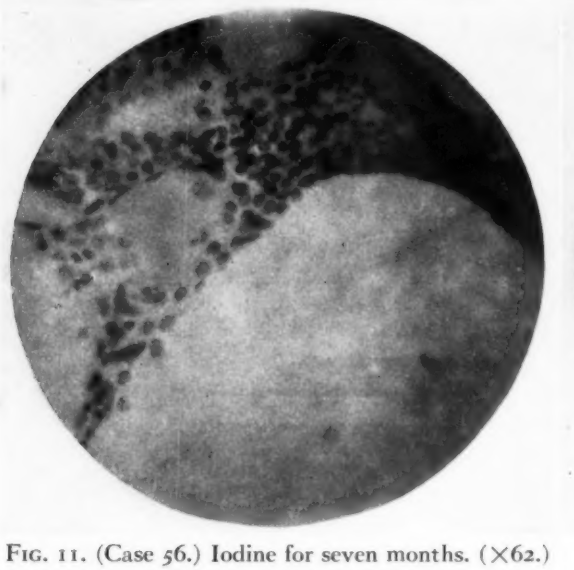

Fig. 11. (Case 56.) Iodine for seven months. (×62.)

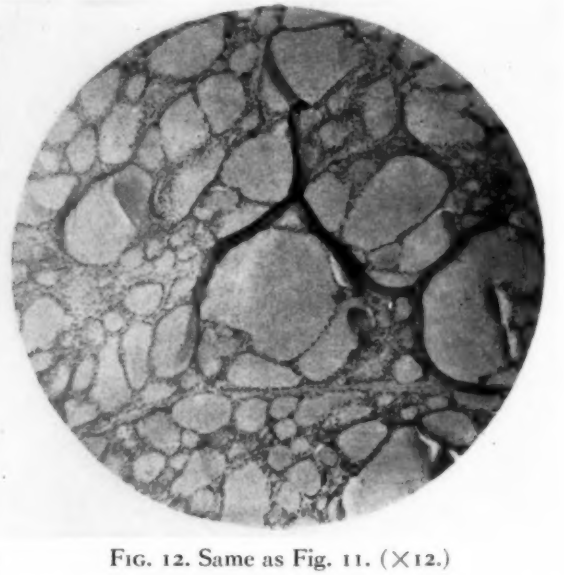

Fig. 12. Same as Fig. 11. (×12.)

PATHOLOGY

The structural changes occurring in the thyroid gland after the administration of iodine have been studied and described by many authors. The essential changes induced consist in an accumulation of colloid, temporary diminution of activity, a decrease in the vascularity, and a reduction in the degree of hyperplasia and hypertrophy. Grossly the gland becomes larger and more firm than the untreated ones. There is visible colloid.

Microscopically intra-acinar colloid is markedly increased and even staining. There is not much tendency to vacuolization. The colloid completely fills the acini and abuts the epithelium. The acini are more uniform in size, and a marked reduction in hyperplasia and hypertrophy is present. Papillary infoldings are flattened or ironed out. Vessels and lymphatics in the stroma are compressed. The lining epithelium of the acini varies somewhat in size and shape, but a low cuboidal or flattened cell is found in most instances. In areas where the gland has resisted the action of iodine the cells tend more to a columnar type. The cytoplasm of the cell is more finely granular. The nuclei are smaller and stand out prominently.

The mechanism of the beneficial effect produced by iodine is a question which is much debated. Several theories have been advanced, none of which adequately answers all questions. Marie believes that there exists at the time a disproportion

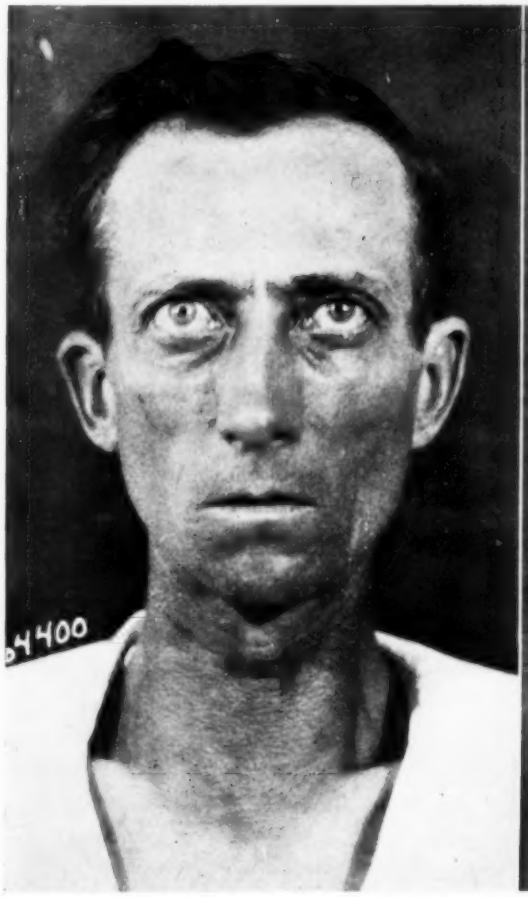

Fig. 13. (Case 54.) Same as Figs. 7 and 8. This patient had taken iodine for six months. Postoperative reaction was very severe and his life probably was saved by use of oxygen tent.

Fig. 14. (Case 57.) Same as Figs. 1 and 2. Case of exophthalmic goiter, probably longest on record, as patient had been on iodine continuously for more than two years.

between iodine content and the requirement of the organism, rather than a deficiency of iodine.

Fig. 15. (Case 50.) Advanced case of exophthalmic goiter. Patient had been on iodine for three months. In spite of careful preparation patient was unable to survive a lobectomy.

Marine explains the effect as being due to a holding back of secretion from the storage of colloid. Plummer writes: "Many reactions which might follow the administration of iodine were considered. The complete iodinization of the thyroxin molecule in the tissues of the body seemed possible but not probable. That the iodine might lead to more complete iodinization of thyroxin in the gland or that it might block its discharge seemed more probable." Plummer also states that irrespective of the degree of stimulation the thyroid will not elaborate much of the abnormal secretion if a sufficient amount of the iodine is available.

As previously mentioned, no one theory will satisfactorily explain the clinical variations found following the administration of iodine to patients with exophthalmic goiter, the short remission of symptoms with improvement in the patient's general condition followed by a return of symptoms, and in most instances with increased severity. There exists no definite relation between the histologic picture and the clinical symptoms.

The photomicrographs are of thyroids removed from patients who had been taking iodine for periods varying from eight weeks to two years; one patient took one teaspoonful of Lugol's solution daily for one year (Fig. 1). We shall not describe the microscopic picture in each individual slide. Areas which were representative of the entire section were photographed. The findings in general correspond with those mentioned previously in this paper. The variations present are chiefly in the amounts of hyperplasia and hypertrophy and in the breaking through the colloid of these areas. Clinically all cases were classified as poor surgical risks. We do not find evidence of exhaustion of the gland as mentioned by Frazier and Mosser.

The clinical and pathological observations on these cases would indicate that the mechanism of the action of iodine is in all probability a combination of factors. Mechanical compression of the cell with temporary inhibition of activity of nearly all areas has some pathological basis for support.

The following table is a brief résumé of the cases of exophthalmic goiter of the "iodine fast" type. These patients were operated on during the past four years. In this same period primary thyroidectomy was performed on other patients with exophthalmic goiter with a mortality rate of one-half of 1 per cent.

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1. Frazier, C. H., and Mosser, W. B. The effect of iodine and thyroid feeding on the thyroid gland. *Ann. Surg.*, 89: 849–856, 1929.

[For additional bibliography see p. 520.]

No.	Sex	Age	Duration of Symptoms	Duration of Time on Iodine	Result of Iodine Treatment	Weight Loss (Lb.)	Blood Pressure	Basal Metabolism Rate		Pulse		Sequelae	Result B. M. R.
								Pre-Lugol's	Post-Lugol's	Pre-Lugol's	Post-Lugol's		
1	F.	42	2 years	6 months	Temporary improvement	40	150/64	+53	+48	98	87	Myocarditis	+14
2	F.	33	6 months	1 month	Temporary improvement	12	148/76	+75	+59	132	104		+ 4
3	F.	23	1 year	4 months	Improved for 2 months	13	118/76	+42	+43	105	106		+ 9
4	F.	32	10 months	5 weeks	Temporary improvement	10	146/60	+61	+55	116	111	Marked dilatation of heart	+11
5	F.	16	10 months	10 months	Improved for 9 months	15	140/76	+54	+47	144	130		0
6	F.	47	7 months	6 months	Improved-heart slower	9	160/90	+44	...	155	...	Auricular fibrillation	- 4
7	F.	52	6 months	6 weeks	Temporary improvement	12	160/80	+49	+40	104	92	Hypertension; myocarditis	+26
8	F.	39	2 years	3 months	Temporary improvement	10	145/80	+47	+41	88	86	Hypertension; myocarditis	0
9	F.	33	1 year	1 year	Temporary improvement	25	98/40	+73	+83	117	108	Hypertension; myocarditis	+10
10	F	15	1 year	6 months	Gained 15 lb.	15	140/65	+65	+36	120	110	Hypertension; myocarditis	Died
11	F.	39	6 months	3 months	Temporary improvement	25	140/55	+55	+37	120	84		+ 8
12	F.	24	7 months	6 months	Temporary improvement	10	130/75	+47	+28	128	100		+19
13	M.	26	7 months	5 months	Less tremor	7	140/30	+56	+40	101	90		+ 2
14	F.	49	3 months	2 months	Gained weight	36	160/78	+55	...	102	...	Hypertension	
15	F.	28	4 months	2 months	Temporary improvement	31	160/68	+93	+58				
16	F.	36	2 months	1 month	Appetite better	32	140/80	+55	+44	115	93		+11
17	F.	41	4 months	2 months	Temporary improvement	5	208/70	+62	+52	119	102	Heart enlargement	+11
18	F.	38	1 year	1 year	Temporary improvement	0	250/10	+95	+33	120	106	Myocarditis; hypertension	
19	F	55	4 months	4 months	Temporary improvement	40	210/120	+55	+43	128	119	Myocarditis; hypertension	
20	F.	15	6 months	3 months	Temporary improvement	10	140/72	+54	+28	122	90		-11
21	F.	36	5 months	6 weeks	Temporary improvement	15	140/70	+ 8	...	90	...		- 3
22	F.	48	4 months	3 months	Temporary improvement	7	118/72	+38	+32	106	90		+ 3
23	F.	29	7 months	7 months	Temporary improvement	17	148/64	+71	+56	100	97	Hypertension	+17
24	F.	50	1 year	3 months	Gained 3 lb.	28	268/80	+60	+50	145	131	Hypertension; myocarditis	+10
25	F.	14	3 months	4-5 years	No improvement	8	140/80	+49	+26	140	125	Myocarditis; hypertension	+10
26	F.	69	1 year	2 months	Improvement	30	210/80	+66	+61	120	102	Myocarditis, hypertension	
27	M.	40	2 years	1 year	Temporary improvement	10	120/80	+65	+30	170	140	Auricular fibrillation	+13
28	F.	29	2 years	9 months	Temporary improvement	12	158/78	+36	+26	115	98	Chronic myocarditis	+23
29	F.	29	7 months	2 months	Temporary improvement	10	150/84	+75	+67	131	116	Hypertension	+12
30	F.	34	6 months	2 months	Improved	4	145/78	+60	...	112	...		- 8
31	F.	66	1 year	9 months	Improved	24	130/70	+48	...	108	...	Myocarditis, chronic	- 9
32	F.	42	2 months	6 weeks	Slight improvement	10	140/75	+59	+37	114	105		
33	F.	34	5 months	3 months	Gained 25 lb.	45	140/74	+55	+63	122	111	Myocarditis, chronic	- 2
34	M.	43	3 weeks	1 week	Slight improvement	17	132/60	+35	+36	83	79		+ 5
35	F.	42	5 months	1 month	Temporary improvement	4	140/84	+29	+23	118	114		- 5
36	M.	45	3½ months	6 weeks	Temporary improvement	18	150/70	+36	...	75	...		0
37	F.	40	1 year	1 month	Slight improvement	35	110/80	+48	+32	105	108		+12
38	M.	69	4 months	2 months	Temporary improvement	39	170/80	+42	+30	100	85		Died
39	F.	31	6 months	1 month	Temporary improvement	12	148/76	+75	+59	132	104		+ 4
40	F.	42	6 years	9 months	Gained 20 lb.	40	150/64	+53	+48	98	87	Myocarditis, chronic	+14
41	F.	66	6 months	6 months	Temporary improvement	52	210/75	+70	+57	120	105	Myocarditis & auricular fibrillation	
42	F.	48	1 year	9 months	Temporary improvement	40	160/70	+81	+84	148	127	Auricular fibrillation	Died
43	F.	45	2½ years	4 months	Temporary improvement	10	200/20	+62	+58	90	85	Auricular fibrillation	
44	F.	25	1 year	3 months	Temporary improvement	20	170/0	+50	...	109	...		+16
45	F.	50	1 year	1 year	Temporary improvement	30	180/90	+52	+66	148	130		+18
46	F.	48	4 months	3 weeks	Temporary improvement	24	150/90	+56	+36	113	97		+16
47	F.	35	2 years	3 weeks	Temporary improvement	10	138/62	+35	+34	108	100	Chronic myocarditis & hepatitis	+ 2
48	F.	33	10 months	4 months	Temporary improvement	40	130/68	+32	...	78	...		+12
49	M.	42	2 years	4 months	Temporary improvement	15	140/78	+25	...	96	...		- 2
50	F.	54	4 months	3 months	Temporary improvement	45	160/80	+43	+37	125	114	Hypertension, myocarditis, auricular fibrillation	Died
51	M.	48	5 months	3 months	Temporary improvement	50	125/60	+49	+33	115	85		+ 4
52	M.	42	4 years	2 years	Temporary improvement	34	155/65	+50	+60	110	95		+10
53	M.	52	6 months	6 months	Temporary improvement	20	160/88	+42	+31	85	84		+ 3
54	M.	43	8 months	6 months	Temporary improvement	30	150/78	+37	+31	100	100		+ 12
55	M.	47	4 months	2 months	Temporary improvement	50	180/86	+60	+39	119	90		+ 4
56	F.	38	1 year	7 months	Temporary improvement	11	150/78	+57	+30	115	87		+ 5
57	F.	24	2½ years	2 years	Temporary improvement	10	150/90	+77	+51	143	139	Chronic myocarditis, cardiac dilatation	- 2

SURGICAL GOITER

HOW MODERN METHODS OF PREPARATION, ANESTHESIA AND TECHNIC HAVE IMPROVED THE SURGICAL RESULTS AND REDUCED MORTALITY TO AN ALMOST NEGLIGIBLE PERCENTAGE*

JOSEPH L. DECOURCY, M.D.

CINCINNATI, OHIO

BEFORE discussing the purely surgical phases of exophthalmic and toxic adenomatous goiter, it may be well to mention briefly a few of the embryologic and anatomic facts that have a bearing on surgical pathology.

The thyroid pouch, the precursor of the thyroid gland, is the first parenchymatous organ to appear in the human embryo. As the epithelial cells of the pouch multiply, a mass is formed, which gradually descends through the developing muscles of the base of the tongue in front of the epiglottis and primitive larynx to the upper part of the trachea.

In the descent, the pouch is drawn out into a tube-like form, known as the thyroglossal duct, which is normally obliterated during fetal life. The mass is now solid, but spaces appear and later become filled with vascular and lymphoid tissue, which ultimately splits the thyroid epithelium into layers of about two cells in thickness.

The concomitant development of the larynx divides the thyroid into two lobes connected by an isthmus. A little later, the layers of cells become separated by a clear substance; finally, a capsule of fibrous connective tissue gradually envelops the mass.

The developed gland lies across the trachea, to which it is loosely attached. The lobes are convex externally and concave internally; the upper poles are conical and the lower rounded. The mean weight of the gland is about 26.11 gm. The right lobe is usually the larger and is also situated higher in the neck than the left.

SURGICAL PROBLEMS

Without further discussion of the anatomy, physiology and pathology of the thyroid gland, I wish to consider the surgical aspects of the problem of goiter together with the preoperative and postoperative care, form of anesthesia, surgical technic and results of thyroidectomy.

PREOPERATIVE USE OF IODINE

The use of iodine in any form of Graves' disease was formerly supposed to be contraindicated, because it was believed that its use increased the severity of the symptoms and might, in fact, be responsible for the development of exophthalmic from simple goiter.

Plummer, of the Mayo Clinic, in 1922 began the use of Lugol's solution as a preoperative measure in the treatment of exophthamic goiter. Ten minims of Lugol's solution were given three times a day for the first ten days and continued up to the time of operation and throughout the postoperative reaction, even though the period before operation might be prolonged for several weeks. After the postoperative reaction, 10 minims daily were given as a routine for eight weeks.

If a crisis occurs, Plummer advises the administration of 50 to 100 minims in divided doses orally or by rectum within one or two hours. By this preoperative use of Lugol's solution, the surgical mortality was reduced from 3.5 per cent to 1 per cent and the preoperative mortality from 2.5 to 3, to 0.2 to 0.5 per cent.

From this time (1922) to 1926, various other observers (Boothby, Mason, Starr and Means, Read, Clute, Merkle and Helmholz, and Holst and Lunde [1929]) employed iodine in the preoperative treatment of goiter and found it beneficial.

There is still, however, great diversity of opinion as to the manner in which Lugol's solution acts; but there is ample

* From the Surgical Section, DeCourcy Clinic. Submitted for publication May 13, 1930.

clinical evidence that its preoperative use in exophthalmic goiter is a safe and beneficial measure, which controls the symptoms, lowers the metabolic rate and lessens the hazards of operation.

When such preoperative treatment is administered, at operation the thyroid gland is found to be edematous. When the gland is sectioned, a watery fluid exudes freely from the incised surfaces. This condition is not found in those cases not treated with Lugol's solution or in the ordinary colloid goiter. This observation has led me to believe that the beneficial effects of preoperative iodine medication are due to a rapid formation of colloid material in the thyroid gland, which is depleted of its normal iodine content. Back pressure from this formation results not only on the cells and acini but also on the thin-walled veins surrounding the acini, and it is this back pressure that causes the passive edema found at operation. The edema of the gland in turn renders the secreting cells inactive, and the absorption of toxic substances is thus prevented; hence, the improvement in the patient's condition.

However, the temporary nature of the improvement can be accounted for by the fact that new blood vessels are formed and the older ones accommodate themselves to the changed condition. Absorption then recurs and the patient becomes toxic, even though colloid formation in the gland may still persist. Marine, who has studied the effects of administration of iodine experimentally, has reached a similar conclusion.

At the DeCourcy Clinic, it is our practice in cases of hyperplastic and adenomatous goiter to administer 10 drops of Lugol's solution three times a day for from two to four weeks preceding the operation, depending upon the degree of clinical improvement and the change in the gland itself, as checked by metabolic readings. In cases of severely toxic adenomatous goiter with cardiac instability or decompensation, patients are placed in bed in the hospital and given a course of digitalis therapy. If there is neither irregularity of beat nor decompensation, 3 doses of standardized tincture of digitalis of 30 minims each are given at intervals of eight hours. If cardiac arrhythmia is present, 10 drops of tincture of digitalis are administered three times a day until compensation is restored. Digitalis is usually discontinued about five days before operation and resumed immediately afterward.

Jackson believes that the surgical treatment of exophthalmic goiter has been revolutionized by the preoperative use of iodine; but he also points out the surgical risk, while admitting the reduction of the surgical mortality to 1 or 2 per cent or less.

Graham states that, while all the phenomena observed after the administration of iodine in toxic goiter are not understood and cannot be satisfactorily explained, its preoperative use is justifiable because of the beneficial effects which have been abundantly proved by clinical experience.

The quantity of iodine necessary to effect the maximum of clinical improvement is determined largely by the size of the thyroid gland and the degree of active hypertrophy and hyperplasia at the time treatment is instituted. Excessive dosage over prolonged periods of time deprive the patient of the valuable therapeutic aid in preparing him for operation, unless there has been an interval of at least a month before its resumption as a preoperative measure. A thrill and bruit over the gland are sufficient indications for resumption of treatment, and complete involution of the thyroid indicates that sufficient iodine has been given and its further use will not likely prove beneficial. However, the drug should not be discontinued immediately preceding operation.

It is doubly important to insist upon preoperative rest and treatment with Lugol's solution when performing thyroidectomy on patients with psychoses, because of the danger of increasing the mental symptoms by a period of exacerb-

ation that might otherwise follow immediately after operation.

ANESTHESIA

Good judgment is required in the choice of a method of anesthesia in goiter operations, and a safe anesthesia is one of the most important factors in the lowering of the mortality rate in such operations. The relative freedom from postoperative hyperthyroid crises is attributed by Pemberton to the avoidance of prolonged general anesthesia and the adoption of special methods of anesthesia as well as to improvement in technic and the preoperative use of iodine.

Crile has adopted the use of nitrous oxide and oxygen with local infiltration almost as a routine in goiter surgery.

Heyd and Smith have employed rectal anesthesia in cases of Graves' disease of severe type. Rectal anesthesia is also used in adenoma hyperthyroidism, but in all other goiters ethylene gas is used.

Pitkin has recommended the use of ephedrine combined with novocaine in block anesthesia as a safe and effectual anesthesia for thyroidectomy. While I have employed spinocaine (Pitkin's method) in over five hundred operations below the diaphragm, and with satisfactory results, I am convinced of the superiority of nitrous oxide and oxygen anesthesia in goiter operations.

Kocher completes the operation under local anesthesia and attributes his low mortality to this method. Bartlett believes the ideal anesthesia for goiter operations is novocaine infiltration and nitrous oxide or light ethylene inhalation. Gwathmey has stated that, when general anesthesia is to be employed, ether and chloroform with oxygen by tube is probably the best method. I do not agree with this conclusion; but with his statement that "those who have never used oxygen with nitrous oxide, and who have acquired the technic of administering it alone, will be surprised by the ease and latitude given by this combination," I do agree.

Some six thousand goiter operations have been performed at DeCourcy Clinic during the past ten years, and several methods of anesthesia have been used.

Five hundred patients were operated upon under local anesthesia. The skin incision, the cutting of muscles and the division of the capsule could be satisfactorily accomplished; but, when the gland was elevated from its bed and the capsule stripped back, there was almost invariably complaint by the patient of a sensation of being strangled. While no pain is felt in many instances, the psychic shock is always undesirable, the time consumed for the operation is usually twice as long as under general anesthesia, and the nervous tension suffered by the surgeon is considerable.

Ether by the open drop method was given to patients who objected to local anesthesia; but it had the disadvantage of a stage of excitement, deep narcosis, postoperative nausea, and disagreeable effects upon the surgeon and his assistants.

Local infiltration combined with nitrous oxide induction and light ether sequence was found quite satisfactory for a time.

About five years ago, however, I began the use of nitrous oxide and oxygen anesthesia for all goiter operations and soon discovered that this method has many advantages. Anesthesia is induced rapidly and recovery is almost immediate, the patient usually becoming conscious before leaving the operating table. Vomiting and retching are reduced to a minimum, and the danger of postoperative hemorrhage is almost completely obviated. The dosage of the anesthetic agent can be regulated to suit the needs of the patient. Injury to nerves can be detected readily by the respiratory rate and crowing inspiration which occurs under this light anesthesia. There is no excess of mucus and sufficient rigidity is present to prevent the falling backward of the tongue and consequent obstruction of respiration. Anesthesia can be deepened quickly, if necessary, and the patient can also be brought back to a safe level by administration of pure oxygen under direct pressure.

While nitrous oxide and oxygen anes-

thesia with proper preliminary medication appears to me to be the method of choice for thyroidectomy, the anesthetist should be skilled in both local and general anesthesia and prepared to administer such anesthetic agents as will produce a well-balanced anesthesia with a minimum of untoward results prior to, during and following the operation. .

TECHNIC OF OPERATION

Without doubt, the successful treatment of toxic goiter must be by thyroidectomy. Medical measures are generally of only temporary avail. They find their greatest field of usefulness in preoperative and postoperative care.

Gentleness of manipulation is of first importance in surgical technic. In fact, the actual steps in the operation are overshadowed in importance by preoperative and postoperative medication with Lugol's solution and the choice of the anesthetic.

In milder cases, a one-stage bilateral partial lobectomy may be performed. A low, transverse collar incision, following the wrinkle of the neck, leaves an inconspicuous scar, which women may hide completely by wearing a necklace. The wound may be closed without drainage if there is no oozing.

In very large hyperplastic thyroids, especially in gangrenous, a two-stage operation is desirable. The thyroid gland is exposed and, after polar ligation, single partial lobectomy performed. If the patient's condition permits, the operation is completed twenty-four to forty-eight hours later.

In all cases, if thyrotoxicosis is to be relieved completely, not less than four-fifths of the entire glandular substance must be removed.

During the course of the operation, the principal accidents against which we must guard include primary or secondary hemorrhage, surgical shock, collapse of the trachea, injury to the parathyroid glands or to the recurrent laryngeal nerves, and air embolism through the large veins of the neck. With careful technic, these accidents are not likely to cause serious trouble.

POSTOPERATIVE TREATMENT AND RESULTS

There is a remarkable improvement in the convalescence of patients who have been treated preoperatively with Lugol's solution, absence of tachycardia, muscular tremor, restlessness and fever. In all toxic cases, the patient is given 30 minims of Lugol's solution rectally, as soon as he is returned to bed, and the dose repeated in about eight hours. In severe cases of exophthalmic goiter, a third dose may be required; but this is rarely necessary when the patient has been prepared properly.

Fluids are given subcutaneously and encouraged by mouth, if they do not cause nausea. In the adenomatous gland, iodine has not been of especial value in the preoperative treatment but has been of distinct value postoperatively.

In a series of 388 operations, 92 per cent of which were upon patients with toxic goiter, there was but one death. This reduces the mortality for the year (1929) to ¼ per cent, a notable improvement over several years ago.

Six cases of hyperplastic goiter were complicated by diabetes mellitus. The patients were prepared for operation by administration of Lugol's solution and insulin and a restricted carbohydrate diet until they were sugar-free. The operations were performed without difficulty and convalescence was uneventful.

Operation alone is not a cure for these patients. The after-care is most important. Skillful nursing, large doses of iodine, warmth and sedatives are necessary. The intelligent coöperation of the patient not only for months, but for years, is an essential for a favorable prognosis.

THYROIDECTOMY FOR MENTAL DISTURBANCE IN ASSOCIATION WITH GOITER

Berkeley and Follis observed a marked resemblance between the symptoms of exophthalmic goiter and those of the catatonic form of dementia precox. During the prodromal stage of catatonia, there was a

similarity of mental symptoms to those occurring in Graves' disease. There were also tachycardia, loss of weight, excessive sweating, fine tremor of the fingers, quick pupillary reflexes, vasomotor weakness and menstrual anomalies. The thyroid gland was not usually enlarged, but was of a soft mushy consistency and contained occasional hard nodules.

The administration of iodine, iodothyrine or desiccated thyroid extract caused a temporary cessation of stupor. These observers performed partial thyroidectomy in 10 cases of catatonia; 4 of these patients recovered their mental equilibrium and 3 improved slowly but progressively with no tendency towards relapse.

Other investigators (Kanavel, Winslow and Weinberg) have confirmed the work of Berkeley and Follis. It must be understood, of course, that there is no attempt to ascribe an etiologic relationship of disturbances of the thyroid gland to the average case of dementia precox; but, in occasional cases, there is a close relationship between dementia precox and thyroid disease.

During the past five years, I have operated upon 14 insane patients with Graves' disease, 12 of whom have made complete mental recoveries and remained normal to date. In 13 of these patients, there was a hyperplastic goiter.

Mental improvement seldom occurs immediately after thyroidectomy but is more commonly gradual, during a period of from several months to a year.

The coexistence of mental disease with exophthalmic goiter does not contraindicate operative procedures, but makes them more advisable, since they offer a fair prospect of mental recovery.

CONCLUSIONS

1. The successful treatment of toxic goiter and the safe one, because it spares the heart and nervous system undue stimulation, is by thyroidectomy.

2. Modern methods of surgical treatment have not only improved results but also greatly lessened the mortality, to less than ¼ per cent at the DeCourcy Clinic.

3. Of first importance is preoperative and postoperative use of Lugol's solution.

4. Second in importance is the choice of the anesthetic. I regard nitrous oxide and oxygen, administered by a skilled anesthetist, as the procedure of choice.

5. By way of technic, extreme gentleness in handling the gland at operation and the use of a two-stage operation in severe cases are essential.

6. In mentally disturbed patients having toxic goiters, thyroidectomy offers a fair prospect of recovery from mental symptoms.

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HYPERNEPHROMA, PAPILLOMA AND STONE

OCCURRING IN HORSE-SHOE KIDNEY*

JOHN K. DE VRIES, M.D.

NEW YORK

TUMORS of the kidney are frequently encountered and hypernephroma is the most common of them all. Abnormalities of the kidney are also common and of these the horse-shoe type is well known. Papilloma of the renal pelvis is likewise frequently met. As for calculus, the condition was known to the ancients and is now encountered almost daily in medical practice. However, I feel that all four of these conditions occurring in a single case is rather unusual and is of sufficient interest to justify this report.

HISTORY

Hypernephroma (so-called) makes up about 85 per cent of renal malignancies. Duffield[1] reports that 87.5 per cent of 25 cases of renal tumors treated at Mt. Sinai Hospital were hypernephromata and according to Albrect[2] 28 out of 32 cases represented this type of tumor.

The typical horse-shoe kidney occurs in about one of a thousand autopsies according to Morris.[11] Renal calculi were found by Kraft[3] (quoted by Keyes) forty times in 2953 autopsies.

Eisendrath[4] has collected 30 cases of horse-shoe kidney, 7 of these patients being operated upon for stone. In the same 30 cases tumor occurred but once and there were no instances in which tumor and stone occurred together.

Stone and tumor are found together, however, and in some cases the tumors are sequelae of antecedent stones. Noteworthy among the cases reported which prove this point are those of Bugbee[5] and Wells.[6]

Primrose[7] in 1920, reported his case of squamous cell carcinoma complicated by calculous pyonephrosis in a horse-shoe kidney. He felt that there was first an irritation set up by the stone and that consequently villous formation occurred in the pelvis and finally malignancy developed by a process of metaplastic changes.

That hypernephromata originated in adrenal rests or groups of cells of adrenal origin which were found in the kidney as well as in other parts of the body, was suggested by Grawitz[8] in 1883.

Stoerk[9] in 1908, claimed that these tumors were of renal origin developing from the renal tubules.

An article on The Origin of Hypernephroma of the Kidney was published by Fraser[10] in 1916. It is here shown that they may be of either renal or adrenal origin. He has demonstrated that the primary structure of tumors of renal origin are different from those of adrenal origin, but that secondary degenerative malignant changes make their histological features similar.

DIAGNOSIS

At one time the diagnosis of horse-shoe kidney was difficult to make preoperatively but since the advent of pyelography it is made much more rapidly. The characteristic points in the diagnosis are:

1. Both kidney shadows are lower than normal.
2. The pelvis and ureters are closer than normal to the midline and rotated.
3. The lower calices point centrally.

CASE REPORT

Mr. L. H., aged fifty-seven, came to see me in May, 1929, complaining of bloody urine. Further questioning proved that he had also had attacks of rather severe pain in the back on the left side over a period of four years. The bleeding had been present only during the past month. His prostate was not enlarged and there was no residual urine, so a cystoscopy

* From the James Buchanan Brady Foundation for Urology of the New York Hospital.
Read before the New York Academy of Medicine, Section of Genito-Urinary Surgery, May 21, 1930.

FIG. 1. Plain *x*-ray. Shadow about the size of walnut indicates presence of stone in left kidney region.

FIG. 2. Left pyelogram. Large distorted pelvis in same field as stone shown in Figure 1. Lower calices point centrally, indicating horseshoe kidney.

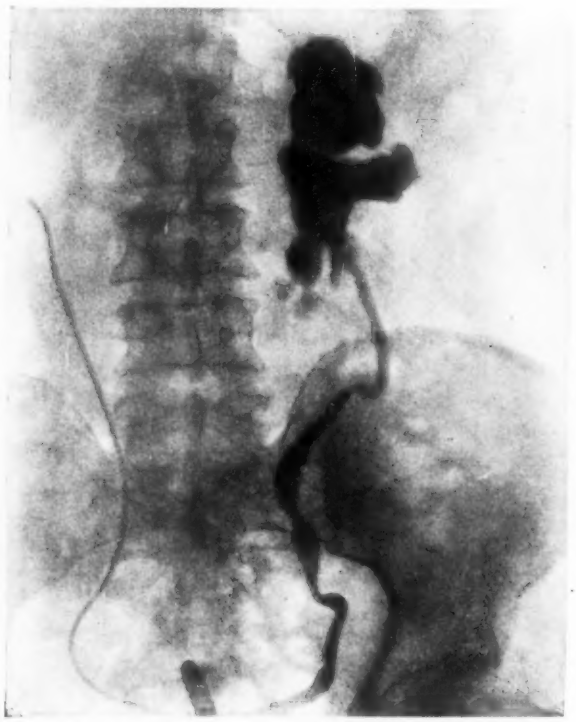

FIG. 3. Left pyeloureterogram. Moderate dilatation of ureter. Lower calices better outlined than in Figure 2.

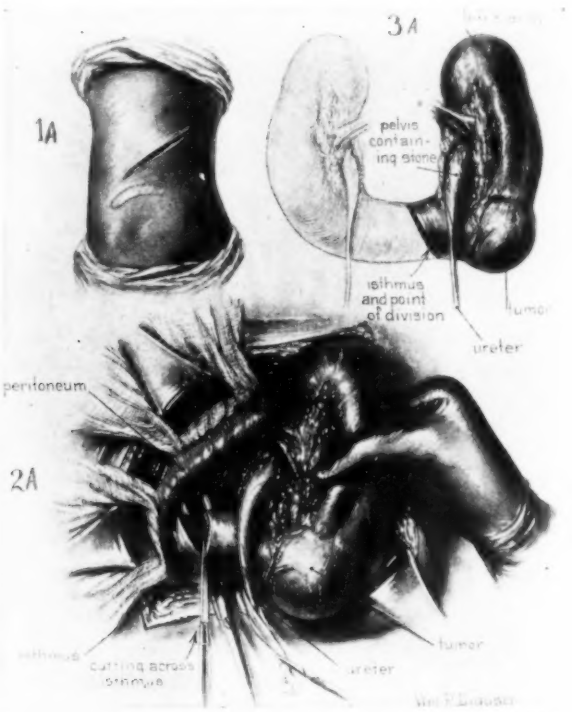

FIG. 4. 1A. Incision begins at point just below middle of last rib and curves downward and laterally to point above anterior superior iliac spine. 2A. Exposure of left side of horseshoe kidney. Tumor is seen at lower pole. Ureter has been ligated and cut. Isthmus is cut across, freeing left side from right. 3A. A thick band of tissue connects right and left kidneys at their lower poles.

was done and a complete urological examination was made.

The bladder appeared normal and no bloody

PHENOLSULPHONEPHTHALEIN		
	Right	Left
Appeared	five minutes	nine minutes

Fig. 5. Plain *x*-ray and pyelogram of specimen after removal. Outline of tumor is here plainly visible.

urine was seen coming from either ureteral orifice. No. 6 lead catheters were passed and specimens were collected for culture, urea determination and microscopic examination.

The cultures were negative, the microscopic examination of the sediment showed blood and pus, diminished urea and phenolsulphonephthalein output on the left side.

REPORT OF URETERAL SPECIMEN

	Right	Left
Character	bloody	bloody
Urea	25 gm. per liter	16 gm. per liter
Per cent	9.5 per cent	trace
Time	ten minutes	ten minutes

MICROSCOPICAL EXAMINATION OF SEDIMENT

Wet Specimen	Many R.B.C.	R.B.C. 200+ pus cells in clusters

Plain *x*-rays as shown in Figure 1, showed a shadow about the size of a walnut in the left kidney region indicating the presence of a stone and a pylogram confirmed the position of the stone and showed the kidney shadow to be low in position, its pelvis and ureter near the midline and the lower calices rotated and

pointing centrally. No filling defect could be seen (see Figs. 2 and 3).

Upon this evidence, and with the assurance that the function on the right side was adequate, the left kidney was exposed with the intention of doing a pyelotomy or nephrotomy for stone.

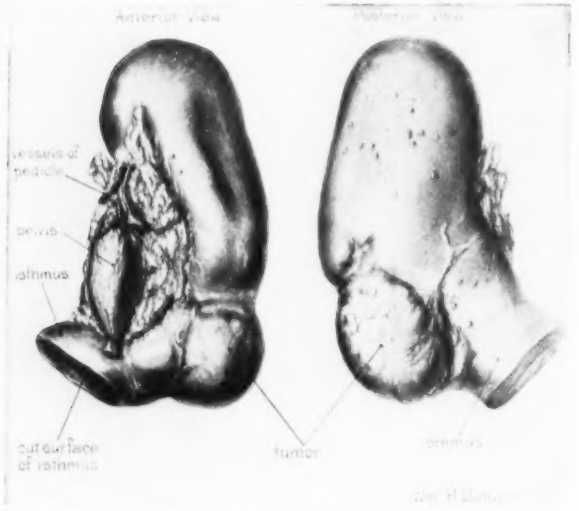

Fig. 6. Artist's drawing. Anterior and posterior aspects of specimen.

OPERATION

An incision was made from a point over the middle of the twelfth rib curving downward and laterally to a point above the anterior superior spine of the ileum (Fig. 4, 1A). The perirenal veins were engorged and as the kidney came more fully to view it was apparent that we were dealing not only with calculus but with tumor as well. The tumor was about the size of a small tangerine, and was situated in the lower pole of what proved to be a typical horse-shoe kidney with a thick band of tissue running toward the opposite side and connecting with the opposite kidney (Figs. 4, 2A and 3A).

Fig. 7. Specimen split longitudinally. Tumor is well encapsulated.

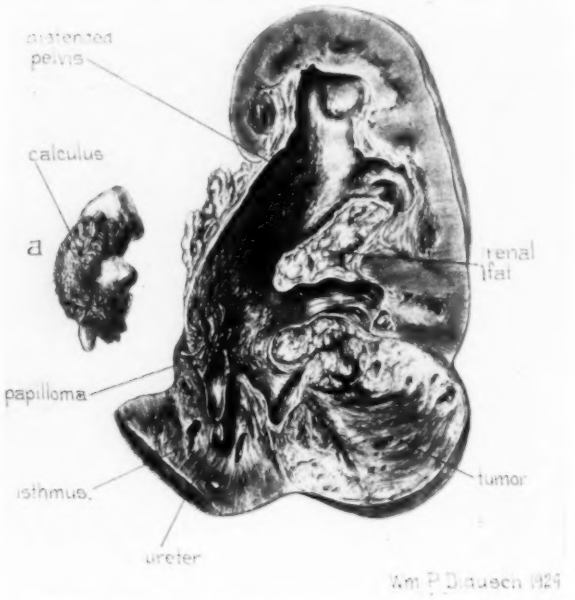

Fig. 8. Drawing. Papilloma is seen in the pelvis. Calculus has been removed and is drawn to scale.

The ureter was identified, ligated, cut and cauterized. Many aberrant vessels were encountered and ligated. Because of these vessels, the pedicle was clamped with two large kidney clamps, doubly ligated and cut. The isthmus was also clamped and cut, and a pad of fat sutured over the severed edge. Drains were inserted and the wound closed in layers.

A pyelogram was now made of the specimen which had been removed. This pyelogram showed not only what the preoperative plates had showed but the filling defect made by the tumor as well (Fig. 5).

The patient's convalescence was uneventful except for a rather high immediate postoperative temperature (104°F.). The wound drained pus copiously for several weeks and finally closed completely two months after operation. He is now alive and well and up to the present time has had no return of his previous symptoms.

PATHOLOGY

Specimen consists of a portion of horse-shoe kidney containing a tumor nodule approxi-

mately 4 cm. in diameter (Fig. 6). The kidney has been subsequently split longitudinally (Fig. 7). The upper pole is of normal outline.

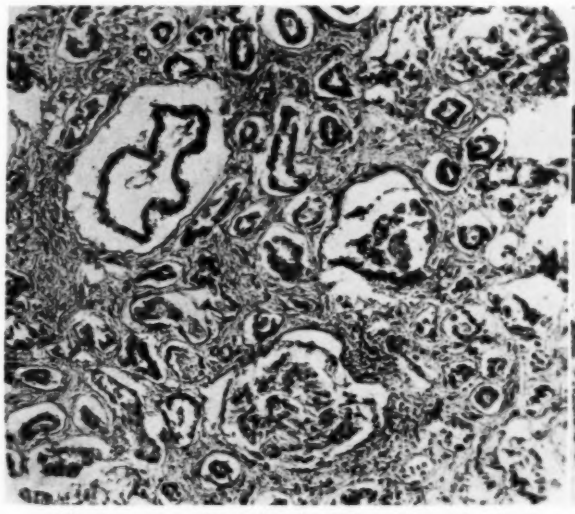

Fig. 9. Moderate pyelonephritis. Distortion of tubules and glomeruli with leucocytic infiltration.

The ureter appears to be derived and situated normally. The pelvis is moderately distended and its mucosa extends to involve the calices which are somewhat flattened. A stone is present in this area and immediately below it the pelvis is thrown into irregular papillomatous folds (Fig. 8).

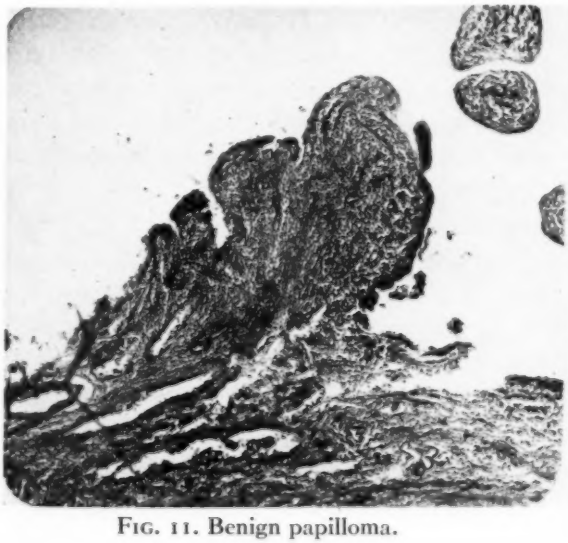

Fig. 11. Benign papilloma.

The main tumor has the general appearance of the so-called hypernephroma, an encapsulated tumor, with a dense fibrous core and radiating fibrous trabeculae of nearly cartilaginous consistency. It is yellowish and red in color, further suggesting the lipochrome or lipoid filled cells of this type of tumor and the usual complicating hemorrhage. No invasion of the surrounding kidney substance or of the vessels is found.

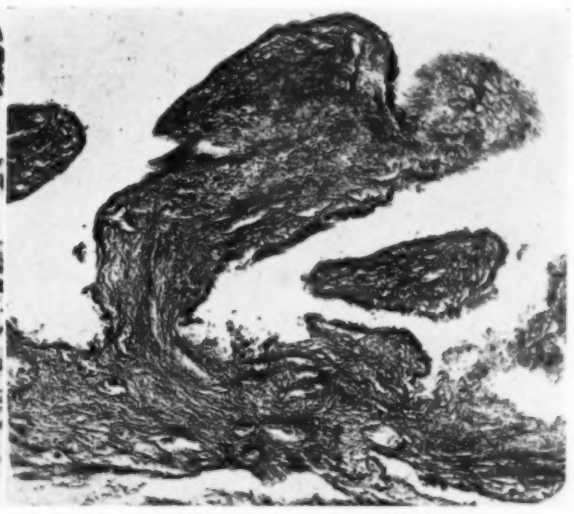

Fig. 10. Papillomata are of multiple benign type.

Sections microscopically through the kidney tissue show a moderate pyelonephritis in the region of the pelvis (Fig. 9). The papillomata in the pelvis are of the multiple benign type some showing a definite connective tissue stalk and some being of the sessile type. All have a typical and orderly arrangement of cells. The tumor itself is made up of large sheets and

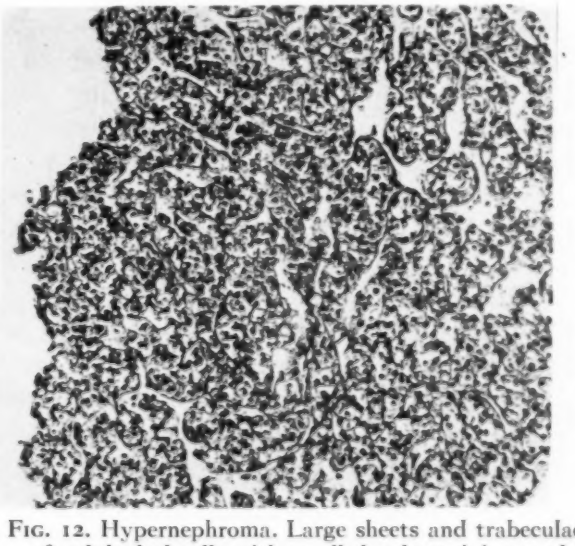

Fig. 12. Hypernephroma. Large sheets and trabeculae of polyhedral cells with small deeply staining nuclei and pale cytoplasm. Some cells are arranged in alveolar fashion.

trabeculae of polyhedral cells containing relatively small and deeply staining nuclei. The cytoplasm is of the type described as foamy. It is very pale and finely vacuolated. Scattered

here and there are found areas where the cells are arranged in alveolar fashion with a definite central lumen. There is extensive degeneration

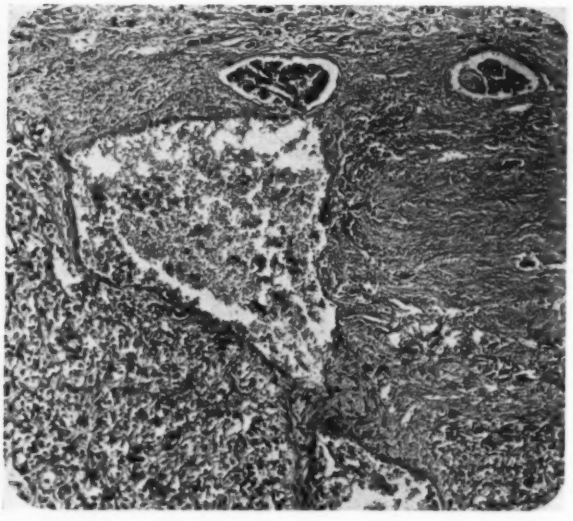

Fig. 13. Line of demarcation between tumor and kidney tissue.

and hemorrhage throughout the specimen. This alveolar arrangement is very suggestive of the so-called clear cell tumors, presumably of renal tubule origin (Figs. 10, 11, 12, 13).

From a prognostic standpoint it appears relatively benign, with few mitoses and no evidence of capsule of vessel invasion.

DISCUSSION

In general it may be said that this group of so-called hypernephromata are of three chief types: First, the tumors with clear cells arranged in alveoli or tubules, tending to show papillary hyperplasia and usually credited with being histogenetically renal in origin, the renal adenocarcinoma; second, the typical, relatively solid Grawitz tumors, showing no true alveoli and usually conceded as arising from adrenal rests; and third, the intermediate group in which these distinguishing characteristics are not well defined and which seem to merge histologically. It is in this intermediate group that this particular tumor must be classified, illustrating the difficulties of a satisfactory classification on the basis of histogenesis. As a generic clinical term, hypernephroma is probably as accurate a label as any which can be attached to it.

It is not uncommon to find stones in horse-shoe kidneys; in fact, they seem predisposed to become complicated by this condition because of the abnormal position of their pelves and the abnormal course of the ureters, producing poor drainage.

There does not seem to be quite the definite relationship between the stone, the papillomata and the main tumor in this case that holds in the case reported by Primrose,[7] for whereas it seemed possible for the squamous cell carcinoma, reported by him to be a final result of metaplasia from a tumor originally growing in the pelvis, here the tumor is definitely circumscribed and situated in the lower pole at some distance from the papilloma.

The histogenesis of this case is difficult to determine because the primary structure of the tumor could not be definitely made out, and although there were areas that suggested tubule formation they were not definite enough to state conclusively that this tumor is of renal origin.

A preoperative diagnosis of horse-shoe kidney with calculus in the left pelvis was made. The tumor was not discovered until the time of operation. Hindsight is better than foresight and the filling defect was made out even in the original pyelogram when the presence and position of the tumor had been made clear at operation.

Heminephrectomy of a horse-shoe kidney does not differ greatly from ordinary nephrectomy, the main differences being that it is more difficult to expose, that there is more likelihood of meeting anomalous vessels and that an added danger from hemorrhage is present because of the incised tissue at the isthmus.

I wish to express my thanks to Dr. O. S. Lowsley for his assistance at operation and for permitting the report of this case from the James Buchanan Brady Foundation. I also wish to thank Dr. L. W. Smith for his description of the pathology.

[For References see p. 468.]

FISTULAE OF THE ABDOMINAL WALL*

S. Thomas Glasser, M.D., C.M.

NEW YORK

IT is difficult to comprehend why there is such a great sparsity in the literature concerning fistulae of the abdominal wall. Every surgeon at one time or another must have been confronted with this problem. Therefore it is of the utmost importance that the prophylaxis, treatment and prognosis of this complication be thoroughly understood. A résumé including the presentation of a few personal observations is our object.

A classification which is simple and yet embraces all types of abdominal fistulae may be outlined as follows:

A. Fistulae to the abdominal wall, more common.

B. Fistulae between two viscera, uncommon.

The latter type, the course of which usually terminates in spontaneous closure, will not be discussed here, nor will we consider fistulae of the genitourinary tract. In the majority of cases, those coming under Class A, either result spontaneously or follow enterostomy. Preoperative indications are, paralytic ileus, intestinal obstruction and peritonitis, or wherever there has been excessive handling of the bowel, i.e., the expectation of poor intestinal response. In all cases other than those due to enterostomy, the formation of the actual fistula is the result of inflammatory processes. These pathological changes occur as follows:

The involved area becomes circumscribed by the "first line of defense," i.e., a leucocytic and fibroplastic barrier whose purpose is localization. The serosal surface of the gut in contact with the inflammatory processes is exposed to degenerative changes which eventually terminate in ulceration and perforation. Thereby is established the internal opening of the fistulous tract; in short, fistulae form where the circulation is impaired. Cicatricial contraction is coincident with and follows the absorption of the inflammatory products. The end-result tends towards a fistulous tract lined by fibrous walls. A serous, mucous or purulent exudate is usually found within the lumen of the fistula. In the majority of cases, the outer circumference of the intestine is in close proximity to the parietal peritoneum lining the anterior abdominal wall. Therefore the fistulous tract is usually a short one. However, other possibilities are, a long tract, or multiple orifices in the gut which may be large or small. Without suitable treatment the abdominal opening undergoes retrogressive changes. Digestion of the muscle wall with extensive excoriation and ulceration of the skin usually result coincident with a rapid enlargement of the abdominal orifice. The higher up in the gastrointestinal tract, excluding stomach, the greater the excoriation and ulceration. Contrary to the prevalent conception, fistulae low down in the intestine discharge pancreatic juices and ferments although to a lesser degree. Gastric and biliary fistulae usually heal spontaneously and are not accompanied by the systemic symptomatology seen in the conditions being described. Once the fistulous tract is established, the discharge becomes profuse and consists of feculent material mixed with intestinal secretions and serous, mucous or purulent exudate. Experience has shown that fistulae of the small bowel heal extremely slowly or not at all, while those of the large intestine invariably close spontaneously with the assistance of ordinary measures. In other words, the higher the origin, the less likelihood is there of spontaneous closure.

The diagnosis of fistula is obvious. Fecal material continually contaminates dressings which require constant changing.

* Submitted for publication August 28, 1930.

Natural bowel movements are absent, or occasional and scanty. The patient rapidly loses weight and becomes pronouncedly weak due to the profuse drainage from the fistula. This illustrates the loss of food intake essential for body nourishment. Fluids and body salts are greatly depleted. Consequently the thermal balance is disturbed and the occasional or daily rises in temperature are present in most cases. Another cause for elevation of temperature is local suppuration with septic absorption. The systemic toxemia is also in great part due to the loss of body chlorides. Starvation is less pronounced the more distal the fistula. To recapitulate, the picture is one of toxemia of varied degree necessitating active treatment in conjunction with care of the local condition.

Fig. 1.

Fig. 2.

Fig. 3.

Fistulae of the abdominal wall are treated as follows:

A. Non-operative:

1. Dressings, local applications, et cetera.
2. Diet and medication.

B. Operative, the last resort.

We have found the C. A. Potter treatment of great value. The rationale of this treatment is based on the fact that pancreatic juices resist healing of the wound. It is only in an alkaline medium that the enzymes are able to act. Therefore in order to combat this chemical action on the tissues of the abdominal wall, hydrochloric acid is used to neutralize the alkaline discharge. Since complete neutralization is not possible, protein is added to counteract the effect of the proteolytic and other ferments. Decinormal hydrochloric acid is used, this being the concentration present in the normal gastric juice. A convenient form of protein is concentrated beef extract. Olive oil is added to counteract bile and lipase. The Potter treatment is summarized as follows:

A. Dress wound every two hours.

1. Cleanse area with alcohol. Dry.
2. Apply tenth-normal hydrochloric acid on a pledget tamped loosely into bottom of crater of the fistula.
3. Cover with gauze dripping of prepared mixture of beef extract and olive oil.

The beneficial effects of this treatment are evidenced in twenty-four hours. Excoriation of surrounding skin and the volume of the discharge are markedly diminished. Progress is rapid.

We have used this treatment with good results in 4 recent serious cases. The illustrations, Figures 1, 2, and 3, are representative of the rapid improvement

experienced. The photographs were taken at weekly intervals, the Potter treatment being instituted in the interim. Warsaw and Hoffman have modified Potter's method by the use of a continuous drip, 5 c.c. per half-hour of decinormal hydrochloric acid and 10 per cent Witte's peptone. One catheter, that used to pass the acid, leads to the fistula; the other serves to soak the gauze with peptone mixture. They claim that the value of this modification is that the patient is not disturbed and the treatment is continuous. Potter's statistics show healing of upper intestinal fistula ranging from three to six weeks. H. Eckstein reports good results with the use of suction. This applies where the etiological factor may have been a foreign body, necrotic tissue, non-absorbable suture material, et cetera. The removal of such bodies by suction apparatus has been followed by rapid cure. There are others who claim the advantage of frequent irrigations with mild antiseptics in conjunction with packing and allowing healing by granulations from within outwards. Our own observations have proved the efficacy of a plug (gauze) in the fistulous opening. This serves to direct the flow of intestinal contents in the normal direction. In all of our cases this procedure has been followed shortly by natural bowel movements. Further treatment of the local condition should consist of the application of heat to the exposed wound, the therapeutic lamp or the ultraviolet ray being used.

Operative treatment is indicated where these methods have failed, or where the patient is rapidly starving or becoming uncontrollably toxic. Tuberculous tracts as a rule necessitate operative interference. Mayo favors excision of the fistula followed by purse-stringing the aperture in the gut. It is often found necessary to resect a portion of the intestine where the enteral opening is too large or where the gut shows sufficient pathology.

It is important to emphasize the necessity of prophylaxis in the prevention of fistulae. The peritoneum and bowels should not be handled unnecessarily, thereby avoiding adhesions. Care must be exercised that no foreign body-feces, non-absorbable suture, gauze, et cetera, be left in the peritoneal cavity. Hard drainage tubes are also a source of danger. These may cause impairment of circulation in the intestine by pressure contact.

SUMMARY

1. Fistulae of the abdominal wall leading to the gastrointestinal tract unfortunately are not uncommon.

2. Non-operative treatment will cure the great majority of these cases.

3. A plug in the fistulous opening is of greatest importance in the non-operative treatment.

4. The C. A. Potter method has proved efficacious.

5. Fistulae to the lower bowel nearly always heal spontaneously.

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COLONIC THERAPY*

FRED D. LAROCHELLE, M.D.

SPRINGFIELD, MASS.

THERE are few problems in physical therapeutics that have given rise to a greater diversity of opinion than colonic irrigation. Some would cure nearly every disease with this, while others would go better and actually defer old age. Another camp looks upon the whole problem with suspicion. In our own work we paid little attention to this matter for a number of years and when we did take up the problem we met with difficulties that readily explain the bad reputation this treatment has with physicians. For instance, if we select an apparatus necessitating the use of the cecal tube, we will find the procedure tedious, difficult and time consuming and oftentimes unsatisfactory and indeed not without danger. Some of the modifications using a two-way tube may be more simple but the results are not so good. Both these types of apparatus make it necessary for the patient to disrobe and necessitate exposure of the parts which is objectionable in all instances. Then the treatment is given with the patient in a recumbent position and this makes it difficult to avoid soiling the table and in many other ways the difficulties are such as to discourage the most enthusiastic operator. Nevertheless if one does persist and give thorough treatments the results obtained will oftentimes well repay the effort. Our aim has been to simplify the technic of this procedure, if possible, and to do away with some, if not all the disagreeable features. One of the first things we learned in studying this problem was, that evacuation and lavage of the colon in a patient in a recumbent position and one in the sitting posture are entirely separate and distinct problems. With a patient lying down the normal mechanism for moving the bowels is almost entirely out of play and the apparatus must in a large measure make up for this deficiency. It is not so with a patient sitting up. This is the natural position for this function and excellent results can be obtained by assisting nature rather than substituting an almost entirely artificial process. We have found the difficulties of colonic lavage in a patient in the recumbent position so numerous and difficult to overcome, that we have practically given up the procedure.

Our first indication for colonic lavage was for preparing patients for operation. Every surgeon encounters at the operating table patients with the colon, specially the cecum, filled with large hard masses. During the few days that follow operation these have to be removed by repeated enemata at the expense of a lot of time and effort on the part of the nurse and untold discomforts to the patient. If the night before the colon is thoroughly evacuated and washed, at operation the large bowel will be found about half the usual size and oftentimes the simple Trendelenburg position will empty the pelvis, obviating the necessity of using packs. After the operation, no attention to the bowels will be necessary for three or four days and then a simple enema will accomplish the desired results. We aim first to empty the whole colon; of course an enema will empty the rectum and sigmoid but this is not sufficient; the transverse colon and cecum must be emptied as well. Then, irrigation or lavage becomes not only possible but easy and whatever virtue there may be in this procedure, can readily be made obvious.

The apparatus we have developed consists of two models, one portable which we presented elsewhere[1] and the hospital model presently described. The principle

[1] *Am. J. Phys. Therapy*, February, 1930.

* Submitted for publication June 10, 1930.

of both is the same and the advantages of the one are that it can be carried in the doctor's bag or used in the patient's home while the other is specially adapted to hospital use where a number of treatments are given daily.

The instrument is made entirely of plated brass and consists of a tube 22 in. long bent in such a way as to readily adapt itself to the conformation of the body and with a removable tip of varying size and handle by which the instrument can be manipulated. In the case of the hospital model the instrument is connected to a 3 gal. reservoir suspended 7 ft. from the floor and connected by a tube and controlled by a valve.

Technic: This is very simple. No preparation of any kind is necessary and the contraindications are such as would apply to an ordinary enema. With the patient sitting on a standard toilet seat, the tip, thoroughly anointed with vaseline is gently introduced through the anus by the patient himself by sense of touch only, without exposure of the parts. When the tip has passed into the rectum the sphincter closes about the tube and all is ready for introducing the liquid. The sense of touch of the rectal mucosa is poor and one scarcely perceives the presence of the instrument. The liquid is forced into the rectum by hydrostatic pressure controlled by the valve in the tube until a sense of fullness with a desire to move the bowels is experienced; the sphincter is then relaxed and the abdominal muscles contracted and the bowels moved in a very nearly natural manner without removing the tip which should remain in place throughout the treatment and without shutting off the supply of liquid. When evacuation has taken place the sphincter contracts again around the tube and the process is repeated until such time as the colon has been completely emptied and washed with soap and water. This should all be done gently and slowly. The tip is then removed by the patient and the colon, instrument and toilet will be found thoroughly clean for being washed with a large quantity of cleansing fluid. For ordinary purposes

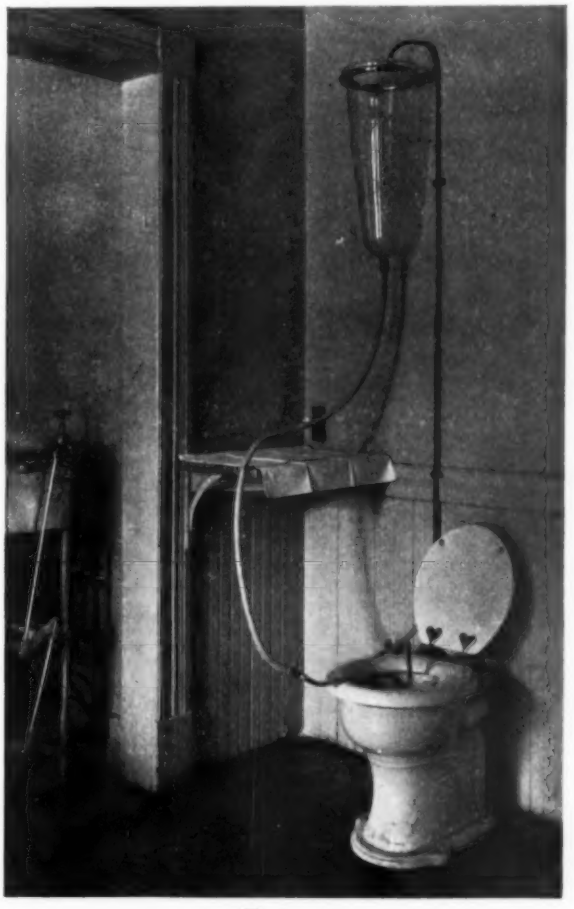


Fig. 1.

soap and water are all that are necessary but glycerin an ounce to the gallon may be added to increase the effect or any other medicament added as desired as with an ordinary enema. The standard quantity of soap is 2 oz. of castile soap to the gallon and this should always be dissolved first by boiling. No solid should ever be added directly to the water in the reservoir for if it is heavier than the water it will pass out first and might reach the colon in too high concentration. It is well to use cool water towards the end to prevent congestion of the rectal mucosa. Five gallons are the usual quantity of soap and water necessary although two or three times that much can be used.

While the apparatus was primarily intended to give colonic irrigations we found it so convenient that we used it for giving enemata which differ only in the quantity of liquid used. We have the apparatus in a special room and the reservoir is connected with hot and cold water. For an ordinary patient with this equipment it takes about one-half hour to secure a thorough cleansing of the whole colon. There is no pain or discomfort and if used with ordinary care there is no danger. We have given over a thousand treatments without accident.

Some men have questioned that the whole colon could be washed with this type of apparatus and we find stated in the literature that it is only with a tube introduced into the cecum itself that this can be accomplished. Any physician can test this for himself by giving a barium enema before the treatment. When a mixture of soap and water is forced into the rectum and sigmoid under sufficient pressure the bowel is distended and made to contract and if expulsion is resisted at the sphincter ani the wave will turn and move up the colon and in this manner will pass over the splenic flexure and eventually reach the transverse colon and cecum. It certainly should be as easy to introduce soap and water into the cecum as it is to insert a tube and once the colon is distended with a stimulating liquid the wave of contraction initiated at the ileocecal valve will sweep down the colon and pour the emulsified contents into the descending colon and result in evacuation. With an ordinary enema tip this would necessarily be removed during moving of the bowels and would need to be introduced each time until a sufficient quantity of solution had been used. This instrument does not aim to replace the enema procedure but rather supplements it by making it more convenient to give a series of enemata and in this wise obtain results beyond that which can be obtained with 2 qts. of soap and water. In our sense colonic irrigation is not to be considered as a novel procedure but as an extended enema. For this purpose the apparatus here presented aims to add to the simplicity and convenience of the procedure and to do away with the discomforts and disagreeable features commonly associated with colonic irrigations.

TELESTEREOROENTGENOGRAPHY*

LOUIS DIOCLES, M.D.

PARIS, FRANCE

HISTORY

IN the Odyssey we read: "I have eyes, two eyes . . . and an interior sensation that results from them without anything strange about it." This would tend to make us suppose that the facts regarding binocular vision were rather confusedly known in the time of the Greeks. This rather obscure text, forsooth, should not astonish us, if, as legend has it, Homer was blind.

We must not conclude, however, that the facts regarding binocular vision remained unknown throughout antiquity. Indeed we find very clean-cut notions on this subject in the works of Euclid, the celebrated Greek geometrician, a contemporary of Archemides, who taught mathematics at Alexandria in Egypt three centuries before our era. His attention had been drawn by the difference in the images in the retina furnished by each of our eyes, just as Porta and d'Augilonius noticed later on. "Seeing in relief," said he, "is receiving by means of each eye the simultaneous impression of two dissimilar images of the same object."

Galen, the great Greek physician, who lived in Rome under Marcus Aurelius in the second century of our era, established the first theory of binocular vision, "The Theory of Identity," based on anatomy and on some observations of hemianopsy.

All these, however, are rather vague conjectures and we have to come down to the end of the 15th century in order to find clearly enunciated the theory of binocular vision. In a manuscript edited at Milan around 1490, Leonardo da Vinci established the difference existing between images of the same object seen by each of the two eyes and the combined image resulting from the superimposition of the two first.

In 1832, Mayo published in "The Outlines of Physiology" a few very definite remarks on binocular vision.

But it was only a few years later, taking as a basis the theories of Mayo, that the English physician Wheatstone thought out an apparatus to show flat pictures in relief. Wheatstone was, as we know, a physician of the first rank, already famous for his measurement of the speed of electricity and by his works on electrical telegraphy. His stereoscope was presented for the first time at the Royal Society of London in June 1838.

Wheatstone's invention was scarcely noticed, and was even completely forgotten when ten years later, Brewster thought out a more practical apparatus by substituting prisms for mirrors, and by placing the two images next to each other.

Despite these improvements, were it not for the discovery of photography, it is probable that stereoscopy would have remained in the domain of the physics laboratories, as did Newton's disk, Mariotte's flask and Madgeburg's hemispheres. The discovery of Niepce and of Daguerre, allowed stereoscopy to soar to its present heights.

It was logical, therefore, because of the powerful interest and the immense development of stereoscopy, to try to utilize its advantages in roentgenography.

The first attempts at roentgenography in relief were made within a few months after Roentgen's discovery, by the Austrian Mach, using two Hittorf tubes. Czermak next conceived the idea of using a single tube and securing the two stereoscopic films by moving the object. Valenta of Vienna, however, it was who first practiced the moving of the roentgen tube.

The first practical results were obtained in France in 1896 by Imbert and Bertin-Sans of Montpellier and reported in a

* Submitted for publication May 15, 1930.

paper read at the Academy of Sciences, March 30, 1896. Shortly after, on November 29, a radiologist of Lyons, Destot, presented a memoir to the Biological Society concerning "The Application of Stereoscopy to the Study of the Circulatory Apparatus."

In 1897, Levy-Dorn in Berlin published a very important memoir on "The Value of the Stereoradiographic Method from the Surgical Point of View."

At almost the same time Marie and Ribaut of Toulouse published[1] their first article inspired by the work of Cazes, "Precision Stereoscopy," which had appeared shortly before at Pellin's.

Since then numerous radiologists have devoted themselves to this branch of technic and proclaimed its advantages. Since we cannot quote all the names of those who have studied this very important question, we will mention those only of Béclère, Belot, Aubourg, Ledoux-Lebard and Halluin in France; Henrard in Belgium; James MacKenzie-Davidson in England; Albers-Schoenberg, Haenisch, Groedel, von Gruenmach in Germany; Wenckebach in Vienna; Carl Beck, Lester Leonard, Dunham and especially Case in America, and Pirie and Pariseau in Canada.

DEFINITIONS

Before we undertake the study of the technic of stereoroentgenography, a few definitions are indispensable. By the name of stereogram we designate a pair of films destined to reconstruct the plastic image. Every region is represented there from two different angles. The reproductions of the same point on the two films bear the name of homologous points.

The separation of the homologous points on the two films increases first, according to the distance between the location of these points in the region being roentgenographed and the surface of the film; and, secondly, according to the tube shift.

Relief in stereoscopy is especially based on the separation and the exact location of these homologous points. Therefore, our attention must bear on these. For reasons of physiological optics, the separation between homologous points should remain within certain limits; otherwise the fusion of the two images is impossible.

THEORY

The analytical exposition of the theory of stereoscopy has been well studied in the "Physiological Optics" of Helmholtz in the chapter entitled "Rules for Stereoscopic Projection." We cannot undertake here to repeat this study or give exact rules for stereoscopic parallax, since this would exceed the limits of our study which is restricted to stereoroentgenography. Suffice it to say, for geometrical, optical and physical reasons, the separation between the homologous points is subject to laws which must be respected if we wish to obtain good stereograms.

The limit of separation of the homologous points has been determined for an average eye and account has been taken in the diverse formulae given for the calculation of the tube shift between the taking of the two films.

The stereoscopic parallax for any given object can be measured by the algebraic difference of the angles of convergence between the first and last plane.

The stereoscopic parallax increases as the interpupillary separation of the observer increases. (Subjects whose pupils are greatly separated are therefore favored from the point of view of stereoscopy.)

On the other hand, there is an advantage in increasing the base of observation. It was this principle which was applied by the telemetrists, a number of whom in the Navy use a base of 10 m. and it is this same principle which we apply in teleroentgenography with a wide base. The parallax increases likewise with the thickness of the object under consideration and when the object is nearer, all other constants remain unchanged.

Stereoscopic acuity is a function of the minimal binocular parallax of a subject.

[1] *Arch. Physiol.*

It is a physiological constant just as is visual acuity, and is exercised like the latter at all distances.

The measuring of stereoscopic acuity is carried out for telemetrists and aviation pilots in the optical laboratory of the Army by means of a test. This acuity is developed by exercise and is lacking only in those individuals who are subject to strabismus or a very marked astigmatism.

TECHNIC

The technic of stereoroentgenography comprises two parts: first, the exposure of two dissimilar films of one and the same region; second, the fusion of these two films for the reconstruction of the plastic image.

The making of the stereoscopic films will differ, from the technical point of view, according to whether we are considering immobile organs such as bones of the limbs or the spinal column, or the viscera whose movements are more or less independent of the will. For the skeleton, the former technic employed by the early roentgenologists is sufficient.

The focus of the *x*-ray tube is moved between the exposure of the two films in a direction parallel to one of the edges. The amount of tube shift represented by Δ was formerly the object of many controversies. We can satisfy ourselves with moving the *x*-ray tube, 6, 7 or 8 cm., which movement will give, according to the thickness of the parts, plastic effects which will be either insufficient or too pronounced. At times, even if we are considering an anteroposterior roentgenogram of the cranium taken at 50 or 60 cm. focal distance, it is almost impossible for observers to fuse the two images.

FORMULA OF MARIE AND RIBAUT

Certain roentgenologists, however, operate with more exactitude and still apply the formula of Ribaut and Marie for the making of their stereograms.

This formula gives the amount of the tube shift between the two films, taking account of the thickness called P of the region studied and the distance called D that separates the focus of the first plane from this region.

First case D-50 or

$$\frac{50(50 \div 10)}{500} = \frac{50 \times 60}{500} = \frac{30}{5} = 6 \text{ cm. } \Delta$$

P-10

Second case D-50 or

$$\frac{50(50 \div 20)}{1000} = \frac{50(70)}{1000} = \frac{35}{10} = 3.5 \text{ cm. } \Delta$$

P-20

In a general way the tube shift $\Delta = \frac{D(D \div P)}{50P}$ increases with D, the focal distance and decreases when P, the thickness of the roentgenographed region increases.

This formula, somewhat lengthy to establish, gives good results for stereograms taken at a short distance.

STEREOROENTGENOGRAPHIC APPARATUS

If we are satisfied, at the beginning at least, with doing stereoroentgenography of the skeleton and particularly of the limbs, the equipment can be very limited. All that is necessray is to immobilize the patient well on a table or a Potter-Bucky diaphragm, and to center the tube on the center of the cassette, this point being very important for obtaining good stereograms. This centering having been made very carefully by means of a plumb-line or any other appropriate apparatus, we then move the tube toward the right, in a direction parallel to one of the edges of the cassette for a distance of 31 mm., or half the amount of the total tube shift. Ordinary tube stands are provided with a graduated scale allowing us to carry out this shift without angulating the *x*-rays.

Under these conditions the impression of relief sufficient for stereograms of the limbs does not allow distinctly the perfect dissociation of the planes and the reconstitution of the plastic image of the pulmonary parenchyma, for example.

THE CONVERGENT METHOD

From the works of numerous authors and from those of Quidor undertaken around 1909 at the Sorbonne in the Laboratory of Professor Delage, it has been ascertained that the notions of distance and relief become more exact when we converge the optical system of the visual apparatus or of any other stereoscopic apparatus.

The study of the angulation of the optical system in photographic apparatus, in binoculars and in binocular microscopes with single objectives, shows the superiority of the convergent method over the parallel method previously described. The works of Quidor reported in his Doctor of Sciences' Thesis, leave no doubt as to the superiority of the convergent method.

"Two methods," says he, "the parallel and the convergent deserve our attention, for each one springs from a different principle." There is also the problem of stereoscopy.

The convergent method is less inclined to force the observer to reconstruct geometrically the space represented than to force him to repeat before the stereoscope the efforts of convergence which direct observation of this space would demand. It is, therefore, more exact than the parallel method, according to Quidor.

The method of rotations has shown, on the other hand, that the sensations of relief were not due exclusively to phenomena of convergence, and that another factor, the inequality of the retinal images of the object observed, played an important rôle in these phenomena.

It is proper, besides, to remember that in the convergent method this inequality of images impresses on the parallax variations which would contribute to render this method more sensitive than the parallel method even if the phenomena of convergence were the only factors of relief. Relief is due then exclusively to the convergence of the visual lines, to the inequality of the retinal images, or to a synthetic action of these two factors. The superiority of the convergent method as compared to the parallel method is completely established; and notions of relief and of distance become more exact. The practical application of this convergent method has been realized in microstereography, in the microscope constructed by Nachet along the lines indicated by Quidor. This apparatus differs from the ordinary model by the angulation which the tube of the microscope can undergo to the left and to the right of the vertical with regard to the plate. This angulation is measured by a graduated drum.

The dark chamber is placed above the microscope and allows the taking of two views of the same object one after the other at two different angles, as with American apparatus; the dental stereographic apparatus of Ritter likewise uses the convergent method, just as all American apparatus does, and the Gaiffe-Gallot-Pilon apparatus has been constructed along these lines.

ANGULATIONS

It is our opinion that the stereoscopic effect is greatly improved and the film more defined when we use the convergent method, for we can in addition, use the diaphragm to the utmost advantage.

With old models and tube stands, the convergent method is not practicable, for the focus, as I said before, should always remain at the same distance from the cassette during the time of changing. In America, on the contrary, where stereoroentgenography is employed systematically, tube stands are provided with a special apparatus allowing the exact angulation of the tube by a direct reading of the graduated scale. This angle measures about 15° in ordinary stereography and the variations are still more important with modern methods.

CRITICISM OF THE OLD CLASSICAL METHOD

In a general way, this calculation, this

minute centering, this perfect immobilization, this tube shift and this angulation, render the method long and difficult. In hospital service, the making of a stereogram under these conditions monopolizes the roentgenographic table and interferes with the service for a half hour, or even an hour at times, because the films often have to be retaken. On the other hand, the inconsistent results due to errors in calculation, to movement on the part of the patient or to the locks immobilizing the tube in its two extreme positions, the difficulty of placing the second cassette exactly in the same position as the first, all of these have a tendency to make us use stereography as little as possible.

Realizing these shortcomings (loss of time and often mediocre results) we sought for more than ten years to perfect this method which was still primitive in spite of the advances of roentgenography. First of all, upon studying closely the results obtained by the best German and American roentgenologists, we realized that the failures, especially for the larger cavities and the thorax in particular, depended on the fact that the pair of stereoscopic films were taken at too short a distance and that the outstanding principle formulated by Druner, that the stereogram should be taken at a focal distance of at least four times the thickness of the part in question, was not always observed.

Advantages of Teleroentgenography

We can imagine then, without any trouble, that a thorax of 25 cm. thickness, stereographed at a focal distance of less than a meter gives a defective plastic result. Therefore in France, we tried to use the teleroentgenography which had been well studied in Germany by Albers-Schoenberg, Groedel and Alban Koehler, and in France by Delherm and Laquerrière, and in particular by a number of American and Canadian roentgenologists. This method presented, in addition, the advantage of giving more definite and undistorted images whose superimposition was effected more easily. Finally, as the climax of this method on the value of which Dr. A. Béclère insisted most particularly, the practical absence of distortion and magnification of the parts most distant from the film allowed the anteroposterior or posteroanterior stereoroentgenographic study of a region which is indispensable to confirm or deny a previous examination.

By using at the beginning American Victor and Kelly-Koett rectifying switches with a Wappler timer, then French Gaiffe-Gallot-Pilon apparatus able to produce 300 to 400 ma. at 150 kv., with a Gaiffe relay timer, we were able to produce routinely good teleroentgenograms between 1 m. 10 and 2 m. 50, this Gaiffe relay timer making it possible to expose films always with the same quantity of *x*-ray radiation with constant results.

From a methodical study pursued for more than three years including the exposure of more than 15,000 films, we ascertained experimentally that in order to save the tubes and to give them the greatest life possible, it was preferable not to use them at several hundred milliamperes with 50 or 60 kv. peak, but, on the contrary, with a milliamperage of 70 to 100 under tensions between 100 and 125 kv. peak. At the present time, we are working at about 118 kv. peak maximum.

Then, since the work carried out under these conditions excited the radiations K of the tungsten target and the intensifying screens, we obtained at these tensions a maximum photographic effect by reducing considerably the time of the exposure and the number of kilowatts received by the anode. Finally, this method has two prime advantages: the economy of tube life and the rapidity of the exposures.

Under these conditions, the making of teleroentgenograms is possible with all modern installations; and at the present time all rectifying switches and kenotron apparatus permit the use of at least 70 ma. at 120 kv. peak, which is sufficiently rapid to obtain good teleroentgenograms.

HYPERSTEREOGRAPHY

Upon examining our two teleroentgenograms made with an ordinary tube-shift base we found out that the plastic effect was clearly insufficient and that a thorax, for example, appeared almost flat since the separation of the homologous points was too small.

Thus it occurred to us to apply to roentgenography for the first time the principles of superstereoscopy which had already given marvelous results in microphotography, in aerial photography and astronomy.

HYPERSTEREO-ROENTGENOGRAPHY

It was logical, therefore, to try to utilize in roentgenology that new science so promising for the future, which, according to Appel, is the equivalent of a true sixth sense. Properly speaking, we are concerned here with a real process of enlargement of our perception of the relief analogous to the enlargement produced by the microscope. It is sufficient to increase the separation of the homologous points by increasing the value of the tube shift Δ while it is within the physiological limits and by preserving the similitude of the forms. We can thus best dissociate the several anatomical planes.

The amount of the tube shift can be very easily calculated by the formula which we enunciated several years ago.[1] This formula, which we have established on advice of Dr. A. Béclère, is based on the diverse theories and laws of stereoscopy and of hyperstereoscopy and also takes account of the physiological factors. Moreover, it has been used experimentally thousands of times over a period of a number of years.

AUTHOR'S FORMULA

Δ tube shift equals P which is the thickness of the part when DF = 8P or a thorax of 20 cm.

Maximum tube shift equals 20 cm. when DF = 1 m. 60. After long personal experimenting the author was able to ascertain the amount of tube shift giving the best results.

In order to avoid figuring for roentgenologists who are short of time, I established a number of formulae which appeared two years ago.[1] These formulae gave, by direct reading and without figuring, the amount of tube shift. When the focal distance is given, it suffices to take the thickness of the part to be roentgenographed with the aid of a thickness gauge or caliper like those we had made by Gaiffe-Callot-Pilon or take one-tenth of the focal distance for the thorax and the abdomen.

AUTHOR'S TELEOSTEREOROENTGENOGRAPHIC APPARATUS (GAIFFE-GALLOT-PILON)

One must make the exposure of the films rapidly; just as those who specialized in visceral stereoroentgenography in a serious way were able to ascertain, it is indispensable in order to obtain a correct plastic effect to take the two films comprising the stereoscopic pair in just as short a time as possible.

Indeed, in taking the two views rapidly we must be careful not to displace the homologous points; otherwise they will produce a false stereoscopic effect. This extremely annoying phenomenon which cannot be avoided takes place likewise in stereophotography when the two views are taken at a long enough interval.

In the first attempts made at Hamburg in 1906 at the Clinic of St. George by Albers-Schoenberg and Haenisch, the large intestine sometimes appeared in the vertebral column because of the segmentary contraction of the colon between the taking of the two views. The same is all the more true for the stomach, the duodenum and the lungs, when in a number of cases, a displaced clavicle or rib or a diaphragm has displaced the homologous points. We were unable to avoid this dangerous annoyance as long as we had at

[1] *J. de Radiol. et d'Electrol.*

[1] *J. de Radiol. et d'Electrol.*, 12: 305, 1928.

our disposition only semi-automatic stereoscopic apparatus or apparatus worked by hand.

kv. peak. Hence the necessity of employing tensions greater than that if we wish to obtain high speed results.

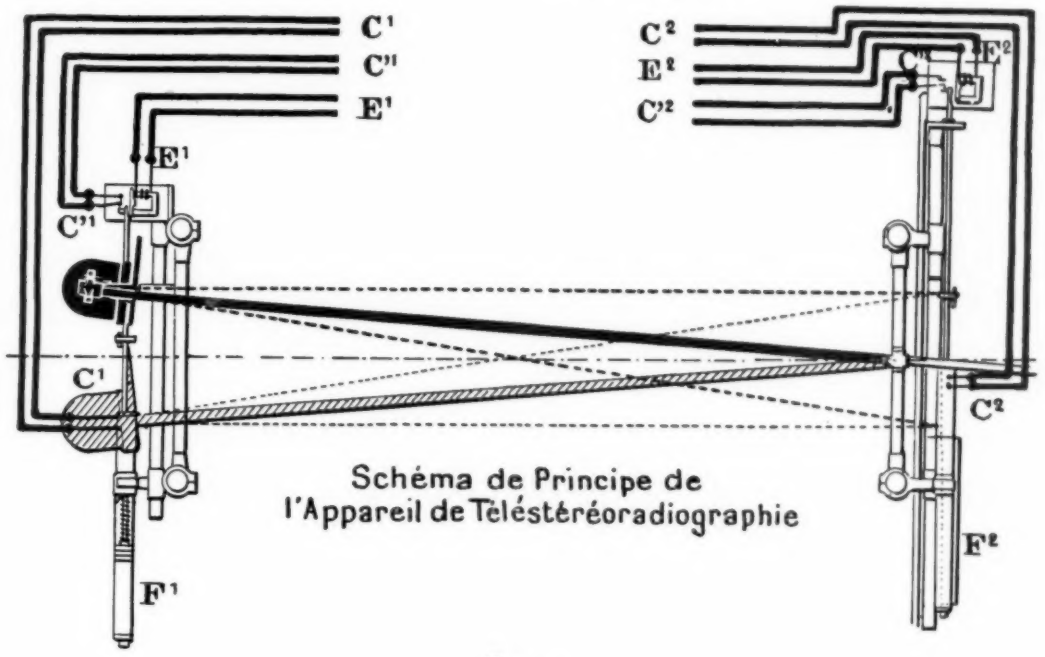


Fig. 1.

Characteristics of a Stereographic Apparatus

The essential characteristics for obtaining an ideal apparatus can be summarized as follows:

First, elimination of all jar and the least vibrations in the changing of position of the cassettes.

Secondly, the possibility of making stereograms in the six vertical classical positions, in all sitting and recumbent positions.

Third, the speed not exceeding one second for the exposure of the two films comprising the stereoscopic pair and the sum total of the movements in changing the two cassettes and the tube.

Fourth, safety. We recognize the necessity of working at tensions of the range of 100 kv. peak if we wish to obtain clean-cut instantaneous films at a correct focal distance by exciting the ray K of tungsten, by an *x*-ray radiation that contains a sufficient quantity of wave lengths of .178 of an Angstrom unit. The ray K is excited with sufficient intensity beginning only with 90

Fifth, simplicity of operation reduced to the simple pressure of an electric button during a fraction of a second only.

Sixth, the realization of an apparatus practical for both operator and patient.

Seventh, extreme rigidity of all parts of the apparatus in view of its automaticity and the rapidity of movements from which are derived permanence and absolute constancy of results, 100 per cent good stereograms.

Eighth, adaptation to technics preferred by each individual roentgenologist. Possibilities of varying the focal distances between 1 and 2½ m. and anode separations between 2 and 40 cm.

The old apparatus would not allow the taking of stereograms in less time then one and one-half to three seconds; thus they were mostly too slow for practical results. Indeed, because of the moving of the homologous points between the two views, these localizations were often false and a tumor, an abscess or a calculous shadow which was in front appeared to be behind. The diaphragm, as Dr. Leo Pariseau

observed in 1925, appeared to be outside of the thorax at times. We can then imagine, without difficulty, the danger

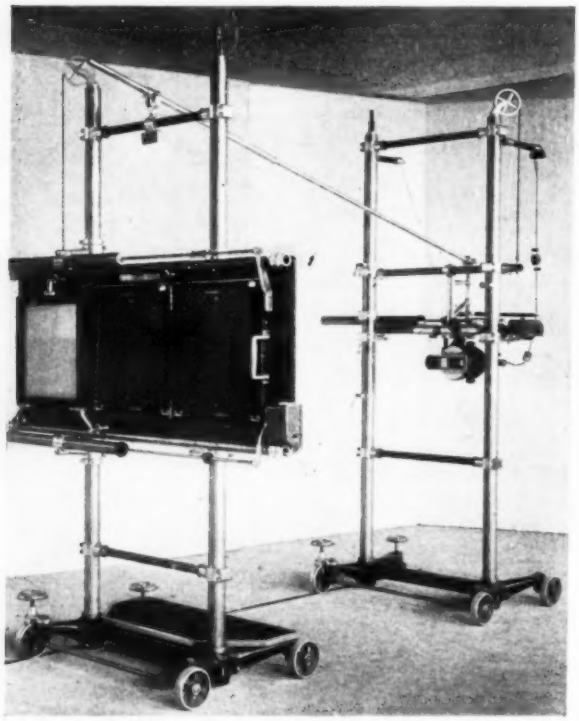


Fig. 2.

that a patient might undergo in having pathology localized in an indefinite way.

For this important reason, we have tried to increase the speed and to have a teleostereoroentgenographic apparatus constructed by Gaiffe-Gallot-Pilon that would be entirely automatic and would allow the making of a stereogram in a fraction of a second (Fig. 1).

This apparatus is composed of two metallic frames placed vertically and parallel to each other, whose separation allows the exposure of films at distances varying between 1 m. and 2½ m. One of these frames constitutes the tube support. The latter can shift from zero to 40 cm., thus allowing teleoroentgenography with a shift of 6 cm., an application of the formula of Marie or of Diocles and the using of the hyperstereoscopic basis indicated in our formula. A set of special diaphragms square, rectangular, circular, oval and in the shape of a Roman window allows the reduction of the secondary radiation to a minimum and obtains good contrasts in spite of using tensions higher than 100 kilovolts peak (Fig. 2).

Fig. 3.

Recently, at the request of Dr. Surmont, Professor of Clinical Medicine at Lille, the author's model has been amplified making it possible to make roentgenograms in a horizontal position. The tube support was simply provided with a new piece which allowed the fixing of the tube in the horizontal position (Fig. 3).

As for the cassette tunnel, it is fixed above a table mounted between the columns of the tube stand. This table possesses a non-opaque top movable longitudinally on ball-bearings so as to easily center the normal ray over the desired region. The fluorescent screen turned towards the floor is seen by reflection in a mirror inclined above it. The focal-film distance may vary between 75 cm. and 1 m. 60. The second framework supports the cassette tunnel and radioscopic screen. The two cassettes are mounted in an apparatus with hinges allowing the rapid substitution of the cassette for the screen. These two frameworks are united mechanically by an extensible rod on a pivot and moving on a joint having a vertical axis of rotation from the tube head in such a

way that the point of incidence of the normal ray is always perfectly centered, no matter what the tube shift and the focal distance employed. All the theoretical conditions are therefore observed in a practical way to obtain the maximum plastic effect.

These movements of the tube and of the two cassettes take place automatically by means of a series of electromagnets and pneumatic brakes which work by friction and slow down toward the end of the course.

Since the operation is electrical, it is very simple. One simply presses an electric button for a fraction of a second in order to get automatic action as follows: the making of the first exposure, simultaneous movement of the tube and the cassettes and the making of the second film exposure. These operations are carried out in less than a second, thus making this apparatus the most rapid of all.

Thanks to a universal arrangement it will be possible henceforth to practice hyperstereoroentgenography of the most movable visceral organs (Fig. 4). The vertical position is preferred for a study of the lungs, the heart, the aorta, the mediastinum and the stomach. For the cranium, sinuses of the face and the mastoids, as also for the cervical column and the upper limbs, the vertical apparatus is likewise sufficient.

The horizontal arrangement is indicated for the study of the duodenum which is particularly advisable in the prone vertical right position, as has been demonstrated by Cole, George and Case in America, Ledoux-Lebard in France and Chaoul in Germany.

The small intestines and especially the pelvic colon and the appendix will be shown better in the horizontal position. This latter arrangement will be especially useful for the making of stereograms of the dorsolumbar spine, the pelvis, and in cases of pregnancy when the exact position of the fetus is to be determined. The horizontal arrangement must equally be used in preference for the lower limbs.

These two arrangements complement each other, therefore, and in combination they make possible, without loss of time,

Fig. 4.

the making of stereograms of all parts of the skeleton and of the viscera.

I recently went to Berlin and saw how an apparatus, because of its fragility, vibrated during the taking of the second film and had to be taken off the market. The big firm of Siemens recently built an apparatus for teleroentgenography based on the principles of telestereoroentgenogram and hyperstereoroentgenography which I have discussed.

This apparatus comprises two tubes. The changing of the films is done by an electric motor which rolls up the film between the two exposures.

SIEMENS-REINIGER-VEIFA APPARATUS

This apparatus has three important drawbacks:

1. It requires a rather long time before the filament of the second tube emits a sufficient number of electrons to permit roentgenography of high intensity.

2. On the other hand, the electric motor provided to roll the film imparts a vibration which is prejudicial to clear detail in the films.

3. Finally, two intensifying screens have to apply themselves exactly over the whole surface of the film at the very moment of the *x*-ray exposure, and this condition is far from being realized in practice. In practice, it has likewise been noticed that the tube shift of 8 cm. provided in the first place was insufficient; and, in these new models, the tube shift can reach 12 cm.

BRAUER APPARATUS

The firm of Brauer at Frankfort-on-the-Main is likewise undertaking the production of a rapid automatic apparatus for stereoroentgenography based on the same principles. I saw this apparatus function at Chaoul's in the service of Sauerbruch at the Charity Hospital in Berlin. This apparatus, of which the second model has appeared, does not yet give me complete satisfaction. First of all, it is impossible to center the tube during the fluoroscopy previous to roentgenographing the part under observation. This condition, which we ascertain from the advice of Dr. A. Béclère, is of prime importance if we want to get the maximum of results in stereography. Secondly in this apparatus, the tube shift is limited to 16 cm. Thirdly on the other hand, the perpendicular shift adopted demands several preliminary mechanical adjustments which are impractical within the desirable limits of technic for the exposure of films of the stomach, the duodenum and the large intestine. Moreover, in spite of the appearance of this new German apparatus, some roentgenologists in Germany employ French apparatus in their institutes and hospitals. In the latest and most modern hospital in Berlin, that of Neukoelln, the author's apparatus functions with the apparatus of Koch, Sterzel and Dresde, with six kenotrons connected according to the method of Graetz, able to deliver 2,000 ma. at the poles of the tube.

For purposes of record only, mention will be made of American apparatus with which the reader may be acquainted, but which presents the important defect of not permitting one to center fluoroscopically and bringing the pathology into observation before the exposure of the films. I will not describe in detail the technic of the making of the films. Those who are interested in this question may be able to come to the laboratories of the hospital of the Hôtel Dieu of Jeanne d'Arc, where every morning between ten and eleven, they will see the making of stereograms according to all the methods that I have pointed out. For purposes of observation, however, the following remarks may be useful. The making of telestereograms of the cranium and the sinuses of the face should be made at 1 m. 10 at about 100 kv. peak and 25 to 50 ma. in the tube, the quantity of electricity varying according to the incidence,—around 100 to 200 ma.-seconds for the profile. In these cases, an average intensity of 25 to 50 ma. is sufficient and the amount of tube shift averages 12 cm. for the profile, 10 cm. for the face, 8 cm. for the base.

Pulmonary work for tele- and stereograms should be carried out at 1 m. 60 average. The average intensity in the tube should be above 50 ma. to obtain sufficient clearness. A tension of 118 kv. peak, 5 ma.-seconds, will be sufficient to obtain a definite and contrasted film. The amount of tube shift according to our formula will be 20 cm. average and may vary according to the thickness of the patients between 16 and 24 cm.

For teleroentgenogram and stereoroentgenograms of the heart, the focal distance that gives the least amount of deformity is 2 m. 50. The intensity of the current ought to be brought up to between 70 and 100 ma. Under 125 kv. peak, the duration of the exposure can be reduced to 7 ma.-seconds on the average. The amount of tube shift can then be brought to an average of 30 cm. to obtain a plastic effect allowing a perfect dissociation of the several anatomical planes.

The whole skeleton of the limbs will give a good relief at 1 m. 10 focal distance. For stereograms of the hand and the fingers, a

tube shift of 24 cm., those of the wrist, the elbow and the tibiotarsal 20 cm., those of the knee and the shoulder 16 cm.

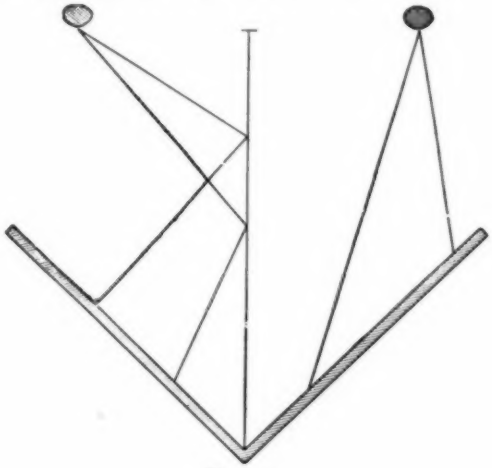


Fig. 5.

EXAMINATION OF STEREOGRAMS

That it is not sufficient to obtain perfect stereograms presenting all the desirable conditions of fineness, contrast and definition, one must learn in addition, to examine them correctly.

In the first place the films made when the tube is to the right of the center should be examined with the right eye and those made when the tube is to the left should be examined with the left eye. If we do not do this we get the effect of an inverse relief which is pseudostereoscopic, and with mirror stereoscopes we might be led into error by placing a lesion to the right which might actually be located to the left.

In our apparatus this error is avoided by the marking of the cassettes with a metallic letter.

1. Direct Examination of Large Films. This examination is carried out with the aid of two types of stereoscopes, mirror stereoscopes and prism stereoscopes.

First, mirror stereoscopes differ according to the number of mirrors.

(a) The type with a single mirror of the Pigeon type, of which a model is made by Gaiffe-Gallot-Pilon, through the courtesy of Professor Hirtz, is good for small sized stereograms up to 24 × 30 cm. (Fig. 5). It is composed of two negatoscopes joined like the leaves of a book. A central mirror movable around a vertical axis allows an orthoscopic or pseudoscopic view according to its orientation (the direction of the rays).

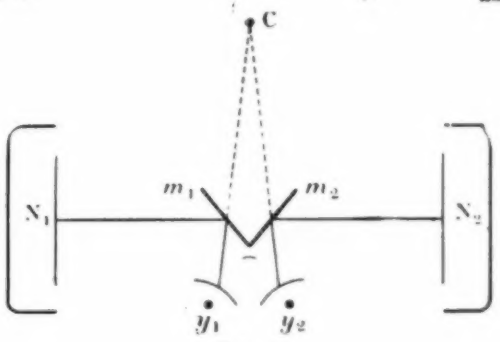


Fig. 6.

(b) The two-mirror stereoscope of the Wheatstone (Fig. 6) type, models thoroughly well made by Victor, Wappler, Gaiffe, etc., is composed of two negatoscopes on which the films are placed, care being taken to reverse them because of the reflection of the mirrors. At the optical center of the apparatus is placed a double set of metallic mirrors allowing the fusion of the images and their reconstitution. Each mirror constitutes an independent optical system and forms an angle with a variable opening regulated by a micrometric screw. A second screw governs the inclination of the optical system around a horizontal axis. Two observers can easily study a stereogram.

This stereoscope, therefore, is the best fitted for hospitals, clinics, and particularly central roentgen laboratories both because of its excellent optical result as well as for the facility it allows of double observation. In America and in England, all the hospital roentgen departments possess a Wheatstone stereoscope.

(c) A stereoscope with four mirrors of the Helmholtz type, of which Siemens built a good model, is especially used in Germany. Its optical result is hardly inferior to the Wheatstone stereoscope, but it is a less cumbersome apparatus.

PRISM STEREOSCOPES

The large sized stereograms can likewise be studied directly by placing them alongside each other in a large negatoscope. The excellent model of Dr. Belot

is perfectly convenient for small sized films up to 24 × 30 cm. For the large sizes, 30 × 40 cm. and 36 × 43 cm., it is necessary to use two pairs of negatoscopes. The type built by Kolen is especially convenient, thanks to the intermediary set which facilitates the centering and the fusion of homologous points. Observation can, therefore, be carried out with the aid of binoculars of different types. First, the stereotelescope of Mattey, the oldest in time, was built primarily for the observation of stereoscopic projections. The conditions under which the examination is carried out are good for stereoroentgenographic films of large size. This apparatus is composed of two biconvex lenses with variable separation to which have been added two biconcave lenses which function as the eye piece and serve for enlarging and drawing images nearer. It is therefore a combination of the stereoscope and of Galileo's telescope (Fig. 7).

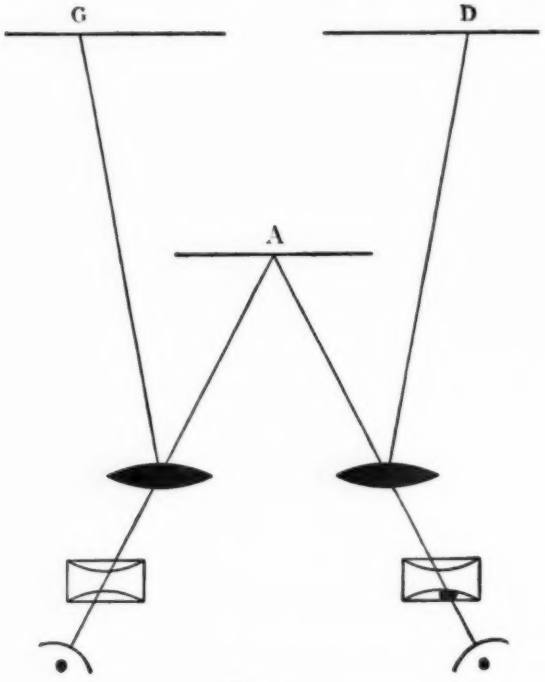


Fig. 7.

The biconcave lenses which constitute the objectives are not placed in the same optical axis as the eye pieces. Their separation is greater so that the biconvex lenses work like prisms and become images each in the opposite sense. The regulation is somewhat delicate because of two adjustments of the eye pieces and the movement of the objectives.

Fig. 8.

It is likewise necessary to keep the apparatus exactly horizontal. The plastic effect is well realized and the image is seen, not reversed, twice as big as normally; but one must examine the films at a distance greater than three times the height, or 1 m. 30 minimum for a film size of 36 × 43 cm.

Secondly, orthoscopic, and pseudoscopic stereoscopes have been made by Richard according to the directions of Colardeau, Professor of Physics at the Lycée Rollin. In the orthoscope the eye piece consists of a prism of 10° and in the pseudoscope a prism of 3°. In these two apparatus, a system of joined diaphragms allows the separation or the bringing together of the openings symmetrically in relation to their axis.

By standing at about 1 m. 30 for the size of 36 × 43 cm., one gets a good plastic effect; and one can study the films without displacing them, both anteroposterior and posteroanterior.

PRISM BINOCULARS

These are binoculars of the shape and appearance of opera glasses (Fig. 8). They consist essentially of two prisms whose bases are turned towards the axis of the apparatus.

The eye pieces consist ordinarily of flat pieces of glass or of biconvex pieces of glass dioptrics in certain particular cases when

it is necessary to study a film in greater detail. The regulation is done very simply by means of a single knurled screw placed in the middle of the apparatus. Examination of large films is carried out at less than 1 m. which allows one to place the two negatoscopes before one on a desk, for example, to study the films, holding the binocular in the left hand whilst making notes with the right. It is very possible to center the binocular over the various parts of the films.

It is our opinion that this is the best apparatus for the radiologist or the practitioner for it allows a very rapid examination of stereoscopic films without fatigue. Its low price and small size and its lightness will popularize its use since it can be easily carried from laboratory to laboratory. It is doubtless the stereoscope of the future.

II. A Study of Reductions. The examination of stereoscopic reductions is carried out in different ways; first, with the aid of a hand stereoscope of the Brewster type, of which there are numerous models (Mattey built more then 400 of them). These stereoscopes are simple, practical and widespread in use because of the wide diffusion of photographic stereoscopy which has a tendency to supplant flat photography more and more.

The optical system of Brewster's stereoscope consists of two prisms with convex surfaces drawn from two thick lenses, 18 cm. focal distance, and whose base rests on the lateral parts of the instrument. The reductions are placed in a groove behind which there is a frosted glass. A vertical board allows either eye to see only the view which it is supposed to see. The focusing is done by varying the distances that separate the reducing prisms.

This stereoscope, of the so-called Mexican type, is very low priced, and can be recommended to patients and doctors for the study of small stereoscopic films. There are also other stereoscopes in which the prisms have been replaced by lenses and which have a focusing device for the eye pieces, the variations of which can be made with very great exactitude. This apparatus consists of a box opaque to the rays of light and is devised to eliminate parasitic images and outside light absolutely.

These stereoscopes are therefore more exact and have a better plastic effect than the preceding apparatus. They are, therefore, serviceable for hospitals and doctors who do not possess large stereoscopes and who desire to study with exactitude the stereoscopic reductions of the roentgenograms of their patients.

A direct examination of the reductions without a stereoscope

But the best stereoscope and the simplest is our own visual apparatus, for with both eyes we habitually perceive the relief of objects and very little training suffices in order to perceive in relief two stereoscopic images. A slight muscular effort analogous to a trial strabismus allows the convergence of the optical axes and the perception of the relief.

At the beginning, it is good to practice with the aid of a piece of cardboard 40 cm. long so that each eye can see only the element which is destined for it. You can see the two images approach progressively and then fuse together; it is sufficient to keep a film exactly horizontal in order to keep homologous points at the same height. That is the way we study our stereoscopic reductions. It is the quickest and best procedure.

At the present time, we can classify the methods proposed up to now for getting good stereoscopic projections into two classes: first, projections with superimposed images where the two images respectively destined for the right and the left eye are projected together on the screen in such a way that each of them comprises the whole of the surface of the screen. Thus, the two images cover each other. Since they are not identical, they cannot superimpose themselves in their entire outline; hence a confused contraction results from their coexistence. Whence the final result will be extracted only as each eye sees but the one image

destined for it. This selection of images can be obtained in three different ways.

(a) By the eclipsing apparatus designed by Mrs. Charles Dupuis and W. Schmidt, D.P. This apparatus is based on the well-known property of the persistence of luminous impressions on the retina. The two images projected on the screen are only lighted up at very close intervals by means of a rotator turning at high speed. Before each observer a second screen animated by movement strictly synchronous with the first, allows each eye to select the image destined for it. This apparatus gives a very beautiful relief with alternations of 30 or 40 per second and if we get a very high stability of the images without a disagreeable jarring produced by certain projectors, this process seems to us especially favored for cinematographic projections in relief.

(b) Apparatus with networks whose principle was studied out by Estanave are very interesting from the theoretical point of view but do not give practical results since the observers have to occupy a very definite position varying within very narrow limits.

(c) Apparatus with continuous illumination. The selection is obtained by the procedure of anaglyphs of which we have already spoken.

PROJECTION WITH A SPECIAL LANTERN

There is on the market a whole line of small lanterns which enable the obtaining of projections in relief. By this procedure before a small audience, the firm of Georges Richard and the firm of Gaumont built models which allow projection of the use of 4½ × 6 cm. and 6 × 13 cm. under good conditions. Mattey has just built a model particularly interesting for radiologists which allows the projection of all the stereoscopic sizes from 4½ × 6 cm. to 8½ × 17 cm. This apparatus, which I was able to examine, works better on our regular electric lighting circuits. The best lantern at the present time for projecting anaglyphs in a vast amphitheater is, in our opinion, the one produced by Gaumont according to specifications of Gimpel and Touchet. The principle is based on the procedure of Almeida and two complementary color screens are interposed in the path of luminous rays. They allow the projection of two elements of the stereoscopic pair in two colors, one green and the other red. Mr. L. Gimpel has shown by his very interesting work that he was not indifferent to choosing such a pair which are complementary to each other and that one was to take account of the physiological effect of the colors on the retina. The best result is furnished by blue-green and red-orange screens whose preparations are made with the aid of a mixture of Hoechst and Tartrezine and carmine-blue for the first and a mixture of eosin and Tartrezine for the second.

The projection is examined with the aid of selective binoculars in such a way that each eye can see only the element destined for it.

The luminous source must be very intense because of the absorption of the screens in a room of large dimensions. It is necessary to have at one's disposition an arc of 40 amp. This point, which should be emphasized, is of very great importance and should draw the attention of doctors who desire to do stereoscopic projections. Indeed, after having used the same apparatus, the same operator and the same views at two meetings, one on Seine Street at the Medical Society of the Hospitals and the other in the Amphitheatre of the Hôtel Dieu in Paris, I found the quality of the projection to be infinitely superior in the latter hall. The variation depended principally on the different electrical energy available.

The arc of the lantern is placed in the center of a large special condenser composed of four lenses of which two are placed so as to receive the bundle of essentially parallel *x*-rays and divides them into bundles which are gathered up by each one of the objectives.

The stereoroentgenographic reduction of the size 8 × 16, 8 × 13 or 45 × 107 cm. is placed in a frame which allows the rays to

pass behind the colored glass. There is, therefore, no modification or coloration intended for it and the view can serve as we have already said, for two purposes: a direct examination with the stereoscope and with projection, which is a valuable double advantage. The objectives of the lantern present arrangements which allow the superimposition of images in the rear planes. The body of the chamber possesses a backward and forward movement which allows the utilization of objectives whose focal distance vary between 150 and 400 mm.

This manner of projection, which utilizes ordinary stereograms on glass, constitutes one of the best procedures for every possessor of a collection of stereoscopic apparatus.

The Projection of Views in Relief with the Ordinary Projection Lantern. For those who do not belong to this category, there exists another method which has the advantage of not requiring the use of the special lantern. It consists in preparing pigmented anaglyphs in which the two perspectives previously printed in orange-red and greenish blue will be superimposed on every film and can thus be examined either individually or in a projection with any lantern, on condition, of course, that we use the selective binoculars.

This means presents another advantage, that of being able to utilize a dimension greater than the small stereoscopic form imposed by the medial separation of the eyes and of allowing one to discover more details in an image reduced only to a size of 8½ × 10 or better still, 9 × 12 cm.

Up to very recently, the preparation of images in colors was complicated and uncertain. Let us recall briefly the long and costly pinatyphe procedure of the fixing of silver images of Dr. Traube and of Abbé Tanleigne, whose first applications to roentgenography are due to Dr. d'Halluin. This method necessitated twelve different operations, at the end of which it was impossible to bring the least correction of a defective correlation. At the Third Congress of Industrial Chemistry, Mr. Seyewetz presented a very complete study of the diverse procedures allowing the transformation of the silver photographic image into a fixer capable of fixing certain colors properly.[1]

From this study, it was evident that the sulphur cyanide of silver process which was prepared by the Lumière Company under the name of "panchromogenous developing" was the one that gave the best result. Its use is very simple since it requires only two baths or four operations with the washings. It offers, moreover, the very appreciable advantage of being susceptible to corrections when the tint obtained presents any defect. Mr. Leon Gimpel used this method of fixing for the preparation of anaglyphs which he presented to the French Photographic Society on June 28, 1929. The colors used are composed of a mixture of a certain proportion of yellow to red and to blue in such a way as to obtain an orange red and a greenish blue complementary to each other.

It is a question of choosing from the existing procedures the one that best answers the needs of the projection of stereoroentgenograms: firstly, if one can take roentgenoscopic monochromes by reduction, and this is perfectly possible, apply the procedure of Ducos Du Hauron; one will need a lantern of only average luminous power and glasses of tinted gelatine. Secondly, if one can use only reductions in black, since light is never lacking now, the procedure of Almeida, which is the most simple, and the lanterns of Gaumont and of Mattey are indispensable. The author prefers the apedioscope of Bellieni in its present form, given it by Massiot, and this for two reasons: One can project the stereoscopic pair directly from the normal from 8½ × 17, 8 × 16, 6 × 17, or 45 × 107 mm., such as it exists for direct vision and without uncoupling it. We use a single lantern provided its condenser has a sufficient diameter. This same lantern eventually lends itself for projecting ordinary roentgenograms.

[1] See *Bull. French Photographic Soc.*, September, 1925.

OBSERVATIONS ON

THE PATHOLOGY OF SURGICAL TUBERCULOSIS

WITH PARTICULAR REFERENCE TO THE INCIDENCE OF TUBERCULOUS BACILLURIA*

R. I. HARRIS, M.C., M.B.

TORONTO, CANADA

IN a disease so chronic as tuberculosis, so insidious in its onset, so obscure in its early manifestations and so slow in its progress, there are many pathological problems which are difficult of elucidation. One of the most interesting and important of these problems is that which deals with the spread of the disease, its entry into the body and its dissemination to distant parts from the primary focus. In patients with bone tuberculosis, this is a subject of importance, though unfortunately it has been nearly completely overlooked. Some details of the present state of our knowledge in this matter may therefore be of value. For too long a time has it been customary to regard tuberculous lesions of bone as isolated examples of the disease. Tuberculosis of the hip, for example, has been looked upon as tuberculosis of the hip and nothing more. In reality it is but the local manifestation of a more or less generalized disease. To treat the disease of the hip alone is to treat the patient inadequately. We must have some knowledge of the place the diseased hip occupies in the pathological chain before we can plan treatment properly.

The sequence of events which leads to the establishment of bone tuberculosis can best be studied in children. In them the disease is of relatively short duration. It is obvious that when tuberculosis of the hip is found in a five-year old child the whole course of the disease from the first contact with tubercle bacilli to the production of the bone lesion must have taken place within that five years and probably within a considerably shorter period of time. It is not a matter of great difficulty to scrutinize the whole period of the child's life and the whole of its surroundings in an attempt to find the source from which its infection arose. This is the more easy since the early years of life are spent in contact with a limited number of individuals. For practical purposes the only contacts with the world have been with members of the immediate family. The number of potential sources of infection is limited and search for the source is easy and successful in a high percentage of cases. In adults the search for the source of the primary infection is more difficult. The onset of the infection from which they suffer in adult life may have occurred so many years previously that search for its origin is hopeless. In adults too the progress of the disease is not the simple picture seen in children. The latter are meeting tubercle for the first time. Their defense mechanism is of a relatively simple type. The disease, if it progresses, marches from organ to organ in a manner which can be followed with relative ease. In adults we frequently, indeed usually, have to deal with fresh infections implanted in individuals who already have a high resistance against the disease. Exacerbations of old foci, and elaborate defense mechanisms which tend to localize the disease in the area of primary invasion, render the picture complex. The pulmonary lesion of adults, for instance, is entirely different from that of children. What follows, therefore, is based chiefly upon knowledge gained in the study of tuberculosis of bone in children.

Children become infected with tubercle bacilli from one of two sources: from human beings with open pulmonary tuberculosis and from the infected milk of tuberculous cattle. As far as I have been able to deter-

* Read before Section of Orthopaedic Surgery, New York Academy of Medicine, March 21, 1930.

mine, from personal observation, neither form of organism has a special predilection for bones. The incidence of either form of infection in bone lesions varies with the incidence of the two forms of infection in the children of any community. There is no special association between bovine organisms and bone lesions. Organisms from both sources infect patients and invade bones in the same way and with the same ease. The great majority of cases are of human origin. The incidence of bovine infection varies in different countries and indeed in different parts of the same country. Nevertheless in every community the question of bovine infection is important since no form of tuberculosis is so readily prevented as that due to infected milk. Unfortunately, the investigation necessary to determine the incidence of bovine tuberculosis in any particular community is tedious, prolonged and expensive. Hence we have been prone to rely upon statistics compiled elsewhere, chiefly from European sources. These really have no bearing upon the problem of communities on this continent. That 50 per cent of Edinburgh's tuberculous children are suffering from bovine tuberculosis has no application to the problem here. Each state or province needs to compile its own statistics. Only by this means will accurate knowledge be acquired, and only accurate knowledge can lead to adequate control. For the Province of Ontario, the incidence of bovine infection in the surgical tuberculosis of childhood is approximately 15 per cent. Such cases all come from homes or communities where raw milk is consumed. To date none have been discovered in cities where adequate pasteurization is carried out. An example of the latter centers is the City of Toronto, where for many years pasteurization has been enforced by law. At the present time 10 per cent of the raw milk coming to the dairies contains tubercle bacilli. In spite of this, not a single case of bovine infection has been discovered during the past five years in which an intensive study of the nature of tuberculous infections has been made. The importance of these observations lies in the ease with which bovine tuberculosis could be entirely eliminated. The painstaking establishment of tuberculous free herds would probably be the best means of attaining this end. But until that day is reached, pasteurization of milk offers a simple and certain means of eliminating bovine tuberculosis. I know of no simpler measure for wiping out 15 per cent of childhood tuberculosis.

Whether the patient be infected with human or bovine organisms the pathway of invasion is the mouth. Bovine organisms are swallowed with tuberculous milk and human organisms are breathed in on droplets of infected sputum with the inspired air. Within the body there is probably no essential difference in their action so that we may abandon any distinction between them. From the mouth, the actual invasion of the tissues takes place along one or more of three main pathways. (1) The bacilli may pass with the inspired air to the lungs where they are deposited in the alveoli and there set up the first focus of tuberculosis. (2) They may be swallowed and after passing through the stomach may invade the intestinal mucosa. (3) They may be deposited upon the nasopharyngeal mucosa and upon the tonsil and there produce primary foci of tuberculosis. Tubercle bacilli of the human type give rise chiefly to the pulmonary lesion, since they are air borne. Bovine lesions are chiefly responsible for the intestinal lesions because they are food borne. Both forms may give rise to tonsillar tuberculosis.

Wherever the tubercle bacilli may have been first deposited (lung, intestine or tonsil) there they set up the characteristic tissue reaction which gives rise to a tubercle. This is the primary focus. The dose of tubercle bacilli may be so small and the natural resistance of the patient so high that the infection is stamped out before it has an opportunity to spread further.

This probably is a rare event. More frequently the disease spreads, not by centrifugal expansion of the primary focus but by way of the lymph stream. In the childhood type of tuberculosis of which we are speaking, the primary focus remains small. Rarely does extensive involvement of lung or tonsil or intestinal mucosa occur. These are characteristics of the secondary invasions which occur during adult life. In childhood the spread of the primary focus is characteristically lymphatic. Tubercle bacilli leave the primary tubercle and pass in the lymph stream to the nearest lymph gland. There they are filtered out and there they set up fresh foci of tuberculosis. From this glandular focus the disease spreads, again by way of the lymphatics, to the next gland in the chain. By a series of such steps the infection spreads from gland to gland until the whole of the lymphatic chain draining the area of the primary focus becomes the seat of a tuberculous process. In this fashion there arises mediastinal adenitis when the primary focus is in the lung; mesenteric adenitis when the primary focus is intestinal, and cervical adenitis when it is tonsillar. By this time sufficient resistance against the disease may have developed to permit its complete eradication. Cure at this stage probably represents the type of tuberculous process through which the majority of us have unconsciously passed. On the other hand, the patient's resistance may only be sufficient to wall up the tuberculous disease behind mats of fibrous tissue where it lies latent, to flare into activity at some later date, when fatigue or intercurrent disease has lowered the patient's resistance.

In still other cases the disease continues to spread. Tubercle bacilli pass in the lymph from gland to gland until finally they reach the blood stream by way of the thoracic duct. More rarely the blood stream may be invaded directly by the rupture of a caseous gland directly into a blood vessel. The invasion of the blood stream and the establishment of a tuberculous septicemia permits the dissemination of the disease to distant parts of the body. The numbers of organisms reaching the blood stream may vary within the widest limits, from the overwhelming infection which rapidly leads to death from miliary tuberculosis, to the isolated organism which is quickly disposed of by phagocytosis. In this consideration of the origin of bone tuberculosis the heavier infections do not concern us. They lead to the production of such myriads of new foci in all parts of the body that death quickly intervenes from miliary tuberculosis or tuberculous meningitis. Such heavy blood stream infections probably are relatively uncommon. It is likely that the less intense tuberculous septicemias commonly occur during the active stage of most cases of tuberculosis. From time to time, scattered showers of tubercle bacilli reach the blood stream from the primary focus or from its accompanying adenitis. In ordinary circumstances, it is probable that these scattered invaders of the blood stream are effectively disposed of by phagocytosis by the reticuloendothelial system. Occasionally, however, an organism or a group of organisms manages to gain a foothold in the tissues and there set up a fresh focus of tuberculosis remote from the primary source of the disease.

That blood stream invasion does occur during tuberculous infection is capable of direct proof. Several observers have recovered tubercle bacilli from the blood of certain cases of bone tuberculosis; one reports the incidence of positive blood cultures to be as high as 50 per cent. I have not found the organisms in the blood with anything like this frequency but in the examination of a comparatively small number of blood specimens I have twice recovered tubercle bacilli. One specimen came from a patient seriously ill with several foci of tuberculosis. He died shortly after the positve specimen of blood was obtained. The second was obtained from a patient with sacroiliac tuberculosis during a period when he was developing fresh bone foci. It is somewhat strange

that this examination of the blood is not more frequently carried out.

Amongst the most common of the hematogenous foci of tuberculosis, which result from this invasion of the blood stream, are those lesions of bones and joints which are grouped together under the heading of surgical tuberculosis. Tuberculosis of the spine and other forms of bone tuberculosis arise by invasion of the bone from the blood stream. It follows, therefore, that every patient with a focus of bone tuberculosis must be suffering from at least one other focus from which the blood stream has been infected. This is true, though it is commonly overlooked. A proper search in most of such patients will reveal evidence of the primary focus. In the majority of cases this will be a pulmonary lesion with its concomitant mediastinal adenitis. Less frequently, the primary focus will be found to be tonsillar or intestinal. Since the primary focus usually is inconspicuous and since its accompanying adenitis, on the contrary, is a prominent feature, the presence of the primary focus often must be deduced from the demonstrable adenitis. X-ray of the chest will reveal mediastinal adenitis when the primary pulmonary focus is so small as to be undiscoverable except by post-mortem examination. Similarly, tuberculous cervical adenitis may be accepted as evidence of a primary lesion in the tonsil. During the past five years it has been our practice to remove the tonsils of patients suffering from tuberculous cervical adenitis as a preliminary measure to removal of tuberculous glands. Examination of these tonsils by section and guinea pig inoculation revealed tuberculous lesions in more than 90 per cent.

Patients suffering from bone tuberculosis display other evidences of the generalized nature of their disease. If there has been a blood stream infestation sufficiently heavy to produce one hematogenous focus, it is possible and even probable, that other foci have been laid down also. A careful search of such cases reveals this to be true. More than half of the patients who suffer from bone foci have multiple lesions of hematogenous origin, either in other bones or in soft tissues. As a rule, one bone lesion is conspicuous, the remaining hemotogenous foci inconspicuous. Yet it is a common experience to see patients with one or more bone lesions and with a variety of soft tissue foci.

Perhaps the most interesting of the soft tissue lesions which may accompany bone tuberculosis is tuberculosis of the kidney. It has not generally been recognized that tubercle bacilli can be recovered from the urine of such patients with remarkable frequency and that their presence in the urine indicates tuberculous disease of the kidney, even when no symptoms are present. One might expect to find tuberculosis of the kidney more frequently amongst patients with bone tuberculosis than amongst patients whose disease is limited to the lung. Renal tuberculosis is a blood borne infection; therefore, it will only appear in patients who have sustained a tuberculous septicemia. Patients who have bone tuberculosis have passed through such a septicemia. Moreover, it has been of sufficient intensity to give rise to focal disease. With blood stream infections of this intensity, it is not unreasonable to suspect the concomitant occurrence of renal foci. Every person who is called upon to treat cases of surgical tuberculosis must have noted occasional cases of renal tuberculosis develop under their observation. The incidence of these obvious cases is not great, but more careful examination will reveal that there are many cases of renal tuberculosis whose existence can be detected only by careful search.

The problem of how frequently renal tuberculosis accompanies tuberculous bone lesions has seemed to us to be worthy of investigation. Consequently, for the past seven years a prolonged investigation has been carried out which has yielded some interesting results. Our procedure is to examine carefully for tubercle bacilli the urine of patients suffering from bone foci.

Urine is collected with aseptic precautions in sterile receptacles. Part of this is examined chemically and stained smears are examined for tubercle bacilli. The sediment from the remainder is inoculated into a guinea pig. At the end of eight weeks the guinea pig is examined and the report recorded. As soon as this report is received, a second specimen is collected and dealt with in a similar manner. A series of such urinary examinations are carried out at intervals of two months as long as the patient is under observation. From each patient there is finally available a long series of urinary reports extending over eighteen months or two years, and in some cases as long as five years.

In all, there have been examined by this method 43 adult patients and 67 children. Of the adult cases 16 (37 per cent) were found to have tubercle bacilli in the urine intermittently or constantly. Among the children, 9 (13.4 per cent) were similarly positive. For purposes of comparison a similar series of observations were carried out upon a number of tuberculous patients without bone and joint involvement. Among these patients (49 in number) 4 (8.8 per cent) had tubercle bacilli in the urine. All 4 positive cases occurred in patients in whom gross invasion of the blood stream had taken place, as was evidenced by the presence of miliary tuberculosis or tuberculous meningitis.

This unusually high incidence of positive urines from patients with bone tuberculosis commands attention. It is far in excess of that generally thought to occur amongst patients with surgical tuberculosis. From my own experience, it may be stated that 5 to 10 per cent represents approximately the number of adult patients with surgical tuberculosis in whom frank renal tuberculosis develops. In children, the incidence is much lower. Naturally the first question which arises concerns the significance of the tubercle bacilli in the urine. Do they arise from tuberculous lesions in the kidney, or have they been excreted by the intact kidney from the blood stream? Before answering this question, we must discuss briefly the nature of renal tuberculosis.

The term "tuberculosis of the kidney" is commonly used to describe a clinical entity characterized by definite symptoms (frequency, urgency and pain), definite urinary findings (pyuria, hematuria and the presence of tubercle bacilli) and pathological changes in the kidney which are macroscopic and gross in extent. Almost invariably these patients come under observation because of their symptoms. Attention is not directed to their urinary tract until frequency, pain and urgency lead them to consult a doctor. The symptoms are bladder symptoms and are due to involvement of the bladder in the disease, either by the passage through it of quantities of irritating material or more frequently by actual extension of the disease to the bladder. As commonly used, therefore, the term tuberculosis of the kidney really means tuberculosis which has commenced in the kidney but has now extended to the bladder and has given rise to symptoms. Of the course of the disease from the onset of symptoms to its termination by operation or death, we are thoroughly familiar; but of the course of the disease from the time the first tubercle bacillus is implanted in the kidney until the involvement of the bladder gives rise to symptoms which attract attention to the urinary tract we know almost nothing. We may term this the preclinical or silent phase of renal tuberculosis. Such evidence as is available leads us to believe that the silent phase is of long duration; that years elapse between the first invasion of the kidney and the extension of the disease to the bladder.

If we assume, for the moment, that tubercle bacilli in the urine of patients with bone tuberculosis come from foci of renal tuberculosis, then a considerable number of these patients are still in the silent phase of the disease. Thus, of the positive cases in adults, 9 (57 per cent) presented none of the usual symptoms of

the disease and in children, 8 (90 per cent) were similarly free from symptoms.

There remains the question as to whether tubercle bacilli in the urine indicate foci of tuberculosis in the kidney, or whether they result from an excretory bacilluria. Extensive investigation into this question leads me to the belief that excretory bacilluria never occurs and that the presence of tubercle bacilli in the kidney urine indicates the presence of renal tuberculosis. The more important reasons for this belief are as follows:

1. The assumption that the intact kidney can excrete tubercle bacilli or other organisms, or indeed any formed particles, is not based upon any facts. Indeed, all the experimental evidence available points to the opposite conclusions. The careful work of Helmholz and his associates demonstrated that organisms never appeared in the urine of an animal following their injection into the blood stream, unless they first produced foci in the kidney. The similar work of Medlar for tubercle bacilli indicates that the presence of these organisms in the urine of an animal following their injection into the blood stream always is accompanied by the occurrence of renal tuberculosis. No experimental or clinical fact has yet established the ability of the kidney to excrete organisms or formed particles of any kind.

2. The tubercle bacilli when present in the urine of these patients are always accompanied by pus cells. The intensity of the pyuria varies greatly and often the number of leucocytes is small. There is a rough parallelism between the number of tubercle bacilli, the number of pus cells and the intensity of the symptoms when these are present. In every positive case, some pus was present. These must come from inflammatory foci, and it is fair to assume that they arise in foci of tuberculous inflammation in the kidney.

3. The kidneys of eight patients who had positive urines have been examined, either after operation or post mortem. In every case, tuberculous disease was found. In some, the lesions were of the usual caverno-caseous type, but in others the foci were small and sometimes few in number. The majority of the kidneys having small foci showed some evidence of healing.

4. From several of the patients daily specimens of urine were collected for a period of two or three weeks and each sample inoculated into a separate guinea pig. In due course, all the guinea pigs developed tuberculosis, demonstrating the constant presence of tubercle bacilli in the urine. Were this due to excretion of tubercle bacilli by the kidney, it must necessarily have been accompanied by the constant presence of tubercle bacilli in the blood. Yet examination of the blood for tubercle bacilli by guinea pig inoculation was negative and the patients did not then and have not since presented any evidence of miliary tuberculosis.

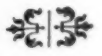
It may be assumed with reasonable certainty, therefore, that the presence of tubercule bacilli in the urine of patients suffering from bone tuberculosis indicates the existence of renal tuberculosis. If this be granted, it is evident that renal tuberculosis occurs more frequently than has been suspected. This discrepancy is very marked in the case of children. During the ten years ending in December, 1926, there were admitted to the Hospital for Sick Children in Toronto 392 patients suffering from bone and joint tuberculosis. Amongst these, the diagnosis of renal tuberculosis was made once (approximately 0.25 per cent). During the succeeding eighteen months, careful examination of the urine revealed positive samples (and presumptively renal tuberculosis) in 13.8 per cent of the cases.

It is of interest to speculate upon the outcome of these cases. Will they progress to frank renal tuberculosis with symptoms, or do some of them undergo spontaneous cure? Too short a time has yet elapsed to answer these questions definitely, but evidence is accumulating which points to spontaneous cure in certain cases. At

any rate, several patients whose urine for a year or more contained tubercle bacilli and pus are now free from these evidences of renal tuberculosis and are free from symptoms. It is commonly stated that renal tuberculosis once established steadily progresses to ultimate destruction of the kidney. But such statements are based upon the experience of genitourinary surgeons, who first see the disease when in a comparatively advanced stage. When gross destruction has occurred, spontaneous cure is not likely to occur. But it is otherwise with the early symptom-free and probably microscopic lesions which can be discovered by routine examination of the urine. It is probable that we must revise our conception of the early pathology of tuberculosis. In this province, the surgeon dealing with bone tuberculosis has an opportunity to gather data which frequently is denied the genitourinary surgeon.

SUMMARY

The occurrence of tuberculosis in bones and joints is but an incident in the dissemination of the disease. It has been possible for it to occur because of the presence of tubercle bacilli in the blood stream. The blood stream in turn has been infected from some preexisting focus of tuberculosis. By reason of its hematogenous origin, bone tuberculosis is prone to be accompanied by other foci in bones and soft tissue which similarly have been infected from the blood stream. The more careful the search, the more numerous will be the lesions found. Renal tuberculosis is particularly prone to accompany bone lesions. In the management of cases of bone tuberculosis, therefore, four things are incumbent upon us: (1) to determine, if possible, the outside source from which the patient was infected, (2) to find his primary focus, (3) to examine him carefully and repeatedly for evidences of concomitant foci, including renal foci, and (4) to treat him as a patient who is suffering from generalized tuberculosis rather than one whose only lesion is in the joint of which he complains.



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*Continued from p. 480.

SPONDYLOLISTHESIS

WITH A REPORT OF FOUR CASES*

SAMUEL KLEINBERG, M.D., F.A.C.S.

NEW YORK

THE purpose of this communication is to report 4 cases of spondylolisthesis in which the dislocation of the fifth lumbar vertebra was evidently due to a congenital deformity of its posterior arch. In 2 cases there was a cleft in the pedicles with wide separation of the superior and inferior articular processes of the fifth lumbar vertebra. In the other cases the laminae were attenuated and abnormally long.

Intensive studies in the anatomy of the back and the pathology of lesions of the spinal column are gradually clarifying what, in the past, have been rather confused notions of certain spinal deformities. It used to be taught that spondylolisthesis was a deformity found only in women. In the last two decades many instances have been seen in men, and in them the lesion was frequently first recognized after an injury. Having treated some cases of spondylolisthesis in laborers, in whom the symptoms and the deformity appeared after a single severe trauma, I was for a time strongly under the impression that, in some cases at least, the lesion was purely traumatic, in the same sense that we speak of a traumatic dislocation of the shoulder or hip joint, the dislocation in the spine being made possible through a fracture of one or both sides of the neural arch. Dr. John Dunlap of Los Angeles in discussing Dr. Elsie Asbury's paper on spondylolisthesis reported 6 patients operated on at the Los Angeles General Hospital, in every one of whom the surgeons found a fracture of the laminae. No evidence was presented in this article to confirm these findings or differentiate them from a possible congenital lack of fusion of the laminae. In view of the studies of Goldthwaite and Willis, the reports of Turner, Shore and Blairsford and my own recent observations, I have been led to modify my conception of the etiology and pathogenesis of spondylolisthesis.

Ever since Thomas Dwight called attention to the fact that the fifth lumbar vertebra had so many morphological variations that he could not describe what constituted a *normal* fifth lumbar vertebra, many observers have recorded a large number of congenital lesions in the lumbosacral area. The most important of these in relation to spondylolisthesis is a congenital cleft in the pedicles due to lack of fusion of the superior and inferior articular processes of the fifth lumbar vertebra on one or both sides. Normally there is only one center of ossification for each lateral mass of a vertebra. When this is split and there are two centers of ossification, the processes developed from them may not fuse. As a result of this the superior articular process is attached to the vertebral body, the inferior articular process joins the lamina, and there is a variable space between these processes filled in by connective tissue. The laminae usually unite posteriorly to form the spinous process; they may, however, remain separate and unfused, resulting in an absence of the spinous process. In the latter condition the defect is distinctly visible in the roentgenogram. When these anomalies are present the vertebral body and the neural arch are held together only by ligaments, and hence they may be separated by any injury sufficiently severe to tear or stretch the ligaments. When, in recent years, cases were said to be traumatic in origin, objection was raised on the score that the alleged accidents were not severe enough nor of a nature to cause a fracture, and that the lesion was, therefore, not traumatic. In the light of our present knowledge the etiology in these cases

*Read before the Section on Orthopedic Surgery, New York Academy of Medicine, May 16, 1930.

becomes apparent. If the injury causes a laceration of the ligamentous tissues, a strong check is removed, and the superincumbent weight of the trunk causes a sagging or dislocation of the vertebral body. This was evidently the mechanism of the dislocation in the first 2 cases here reported.

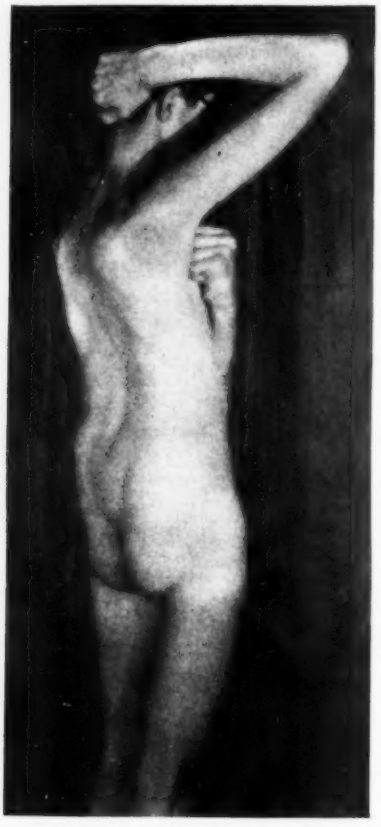

Fig. 1. Case 1. Side view, showing prominence of sacrum and marked hollow in lumbar region. The back is flat. The prominence of the iliac crests is not visible in this view.

An increase in the lumbosacral angle is another potent factor in the causation of spondylolisthesis. There may be combined with this a change in the shape of the superior surface of the sacrum. The upper surface of the sacrum may be convex and its anterior half slope downward and forward, as is distinctly seen in the lateral *x*-ray picture of my first case. In this anomalous condition the strains and stresses of the body weight tend, during ordinary occupation and without any single severe injury, to initiate a subluxation of the last lumbar vertebra.

An alteration in the plane of the lumbosacral joints would also favor subluxation of the fifth lumbar. We know that the articular processes of the lumbosacral joint vary a great deal in the shape, position and direction of their articular facets. The articular processes are frequently not symmetrical. The outline, size and general inclination of the joint on one side may be different from those on the other side. The plane of the articulation on either or both sides varies from the vertical to the horizontal position. Thus while in the normal state of the lumbosacral articulation a dislocation is not possible because of the relation of the articular processes of the fifth lumbar and sacrum, when the plane of the joint is altered so that it is oblique or horizontal, the processes can readily slip past each other.

Dr. J. C. Edgar in his textbook on "The Practice of Obstetrics" suggested long ago that the subluxation of the vertebral body in spondylolisthesis may be due to an elongation of the laminae. In two of the present group of cases and in others I have studied, the lateral *x*-ray film showed what did appear to be abnormally thin and very long laminae without any break in their bony continuity. More convincing proof is now offered by Dr. Brailsford of England who reports 5 cases and 1 specimen of spondylolisthesis. In all but one of these the laminae were elongated and showed no solution of continuity. He noted further that in the anteroposterior films the neural arch increased in width from the second or third lumbar down to the middle of the sacrum. This increase is due to a lengthening of the laminae. The changed structure of the laminae is the result of a congenital malformation or perhaps a sequel to an injury during childhood.

The relation of injury to spondylolisthesis is difficult to estimate accurately. In most of the cases I have seen the symptoms appeared directly after an injury. Dr. Elsie Asbury of Cincinnati, Ohio, in a study of 27 cases found that trauma played an important part in 23 of them. Most authors are agreed that

trauma is a prominent factor in the etiology of the majority of the cases.

When we consider spondylolisthesis as occurring in an individual who is predisposed to this lesion by reason of certain congenital bony maldevelopment or anomalies, it is readily understood how a single severe trauma or a succession of injuries may operate in bringing about a true dislocation with motor and sensory disturbances and a variable degree of disability.

Fig. 2a. Case 1. Characteristic crescentic shadow of body of fifth lumbar vertebra in front of upper part of sacrum. Defect in neural arch of fifth lumbar is clearly shown.

Fig. 2b. Case 1. Anteroposterior view made at lower level than that shown in preceding figure. Outlines have been purposely emphasized by pencil to show more clearly defects in fifth lumbar and sacrum.

CASE REPORTS

Case 1. Lionel S., fourteen years old, was referred to me in September, 1928 for pain in the lower part of his back, pain in his lower limbs and difficulty and awkwardness in walking. He was apparently well until March, 1928 when, while climbing up a hill, he stumbled and fell backward, striking the lower part of his back against a rock. He had only moderate pain at the time and after a few days forgot the accident. He returned to school and finished his term. During March and April, 1928, he engaged in the usual exercises and games with his playmates. In May, however, he found that he could not run as fast as his comrades or as fast as he used to. During the summer months he went swimming and apparently had backache only when he chanced to brush against someone, or somebody pressed against his back. He does not remember when his awkward gait appeared. Soon after the injury he began to have pain in the back of his lower limbs. The pain gradually increased and recently became severe. The pain has always extended from his back down the back of both thighs and legs to the ankles.

My notes of September 26, 1928 read as follows: The boy is very tall for his age, thin and anemic. He walks without assistance but very awkwardly, swaying his pelvis. There is a very peculiar deformity of his back as is seen in Figure 1. His back is symmetrical. The sacrum and iliac crests are very prominent. Immediately above the sacrum the spine curves forward sharply, so that there is an exaggeration of the lumbar curve. The lordosis includes all the lumbar and the lower dorsal vertebrae. There is a reduction in the normal backward curve of the upper dorsal vertebrae, so that the patient has a flat back. There is exquisite tenderness upon pressure over the lumbosacral

area. The motions of the spine are markedly restricted in all directions. There is no disturbance of sensation. The reflexes are normal.

Fig. 3. Case 1. Lateral view showing anterior dislocation of body of fifth lumbar, and interval between body and lateral mass of fifth lumbar. Axis of sacrum is nearly vertical.

The roentgenograms are characteristic of spondylolisthesis. In the anteroposterior view, Figure 2, the upper 4 lumbar vertebrae have the normal outlines. The fifth lumbar is not above the sacrum. Instead, one sees a typical crescentic shadow in front of the first sacral segment. This is the body of the fifth lumbar. Immediately above the sacrum there is an elongated process of bone parallel with the upper border of the sacrum (Fig. 2 A). This, which I assumed to be the neural arch of the first sacral segment, proved, at operation, to be the malformed neural arch of the fifth lumbar vertebra. The outlines of the vertebrae were, for convenience, emphasized by pencil in the original film before copies were made for publication. In the lateral view (Fig. 3) the body of the fifth lumbar is seen to be displaced forward. There is a gap or cleft between the body and the lateral mass. It is noted also that, as Dr. Goldthwaite has pointed out, the axis of the sacrum is more vertical than in the normal individual.

This patient has, therefore, an advanced degree of forward dislocation of the fifth lumbar vertebra. From the course of the boy's illness, the chief element of which was progressive aggravation of backache and disability, we may conclude that the dislocation, made possible by the existence of a defect in the structure of the fifth lumbar, started at the time of the injury and gradually increased. The injury was but like a spark starting a flame. It caused a tear or stretching of the ligamentous tissues holding the bony elements. Subsequently there was a progressive slipping of the vertebral body with the appearance of a deformity of the spine and nerve symptoms causing practically complete disability.

In the hope that we might effect some measure of reduction by favorable posture and traction, the patient was placed in bed, the thighs flexed and traction applied to the head and to the thighs in the direction of the axes of the femora as shown in Figure 4. Within several days the pain in the thighs and back and the tenderness in the lumbosacral area disappeared completely, and the boy was comfortable for the first time in several months. Upon palpation of the spine it was found that the lumbar area was flat instead of hollow. The depression above the sacrum was gone. From these observations it was hoped that the dislocation was partly reduced. The *x*-ray pictures, however, showed that there was no such fortunate result. As the pain was relieved I concluded that the traction did remove pressure from the lumbar nerves.

The next step in the treatment was inevitably a spine fusion for the purpose of uniting the lower lumbar vertebrae to the sacrum, and preventing further displacement of the fifth lumbar vertebra. The stabilization of the entire lumbosacral area would tend to relieve the pressure on the nerves and the disabling pain.

The operation was performed about three weeks after the patient's admission to the Hospital for Ruptured and Crippled. The posterior arches of the second, third, fourth and fifth lumbar vertebrae and of the upper part of the sacrum were bared of periosteum. The pathological findings noted at the operation are represented in the accompanying sketch (Figure 5) made for me by the then House Surgeon, Dr. M. H. Herzmark, who assisted me. The fifth lumbar vertebra did not have a

spinous process. The laminae were not fused. There was an interval between the two lateral masses of the fifth lumbar of at least a half-inch. The posterior arch of the fifth lumbar vertebra was abnormally movable and the two lateral masses were movable upon each other. On the right side the lamina and transverse process were easily identified. On the left side the mass of bone exposed in the wound was evidently the posterior extremity of the lamina. The transverse process could not be found. Apparently there was rotation of the vertebra as a result of which the anterior part of the lamina and the transverse process on the left side were so deeply placed that they did not come into view. The lateral masses of the fifth lumbar vertebra articulated with the sacrum. Beyond the articulations the lateral masses of the sacrum were visible for a distance of about a half-inch. There was a wide defect in the posterior arches of the first and second sacral segments. A large beef bone graft was inserted on the left side of the spine from the second lumbar to the third sacral segment.

Eight weeks after the spine fusion the patient was discharged from the hospital wearing a Knight spinal brace. At present, one year and a half after the operation, he walks about comfortably and has no pain.

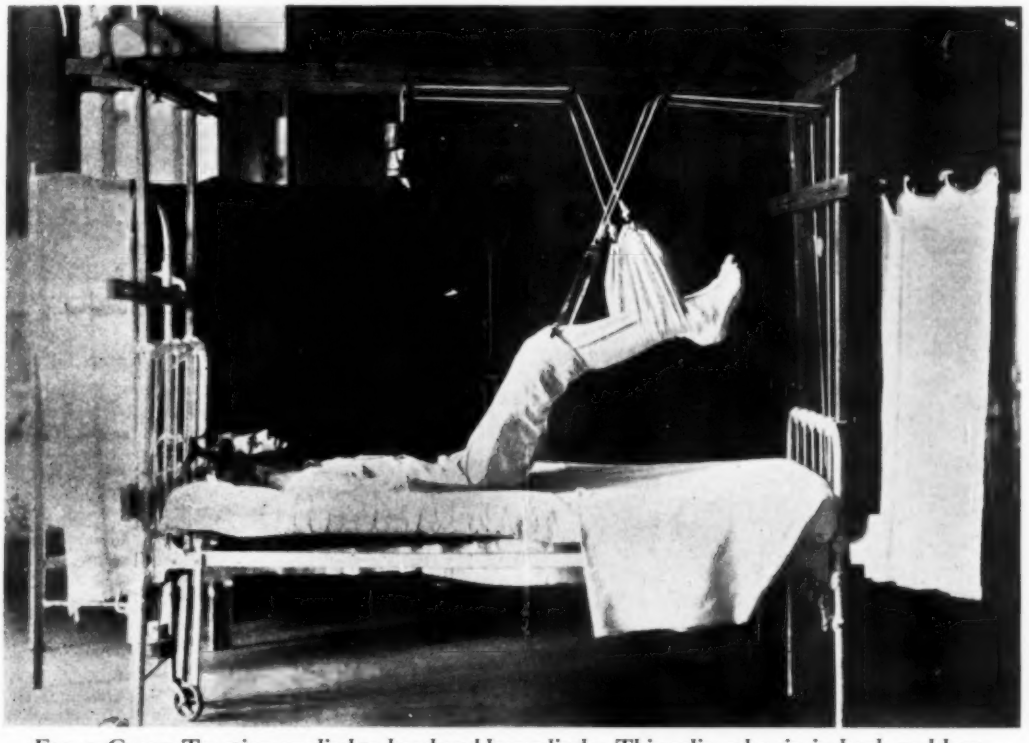

Fig. 4. Case 1. Traction applied to head and lower limbs. This relieved pain in back and legs.

Case II. John McC., twenty-three years old, came to my clinic at the Hospital for Joint Diseases in December, 1929. His chief complaint was weakness of the back, and pain in the lower part of his back and along the posterior aspect of the right lower limb. His symptoms came on gradually about a year ago, after he had engaged in lifting some heavy weights. This patient had several severe falls that probably contributed to the present disability. Three years ago he fell and was so severely hurt that he was unconscious for ten minutes. On another occasion, in trying to save himself during a fall, he fractured his right foot. But the backache is only of about a year's duration and is at present aggravated by any strong muscular exertion.

The patient is a young man apparently in excellent general condition. He walks without assistance but awkwardly. His back is symmetrical. The trunk is inclined forward and slightly to the right. There is marked prominence of the sacrum and a hollow above the sacrum. The dorsal area is unusually flat. Flexion and lateral bending of the spine are free. Hyperextension is moderately restricted. There is no tenderness to pressure over any part of the back.

The lateral *x*-ray picture (Fig. 6) shows a

marked forward subluxation of the fifth lumbar vertebra. The anterior surface of the body is three-fourths of an inch in front of that of the

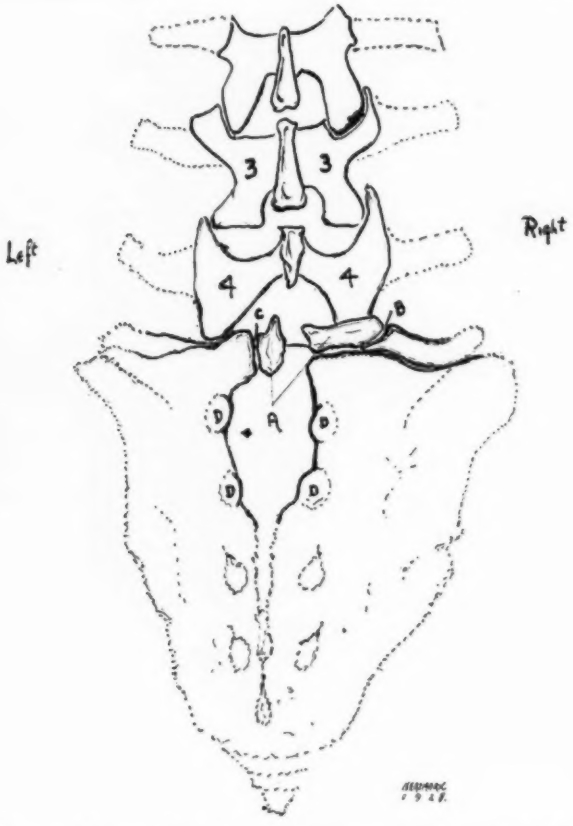

Fig. 5. Case I. Operative findings. A. Laminae of fifth lumbar with a wide gap between them. B. Facets of right lumbosacral articulation nearly horizontal. C. Facets on left side are vertical. D. Extremities of laminae of first and second sacral segments with large defect in neural arches.

sacrum. The body of the fifth lumbar is wedge shaped, with the base corresponding to the anterior surface. The vertical diameter of the posterior surface of the body of the fifth lumbar is less than half of that of the anterior surface. There is a very wide gap between the pedicle of the fifth lumbar and its spinous process which remains alined with that of the first sacral segment. The upper lumbar vertebrae appear normal and are all displaced forward and alined with the body of the last lumbar vertebra. The upper surface of the sacrum is convex upward. The long axis of the sacrum is almost vertical.

This is evidently a case of congenital spondylolisthesis, like the preceding one, in which there is a lack of fusion of the front and back portions of the laminae. The division is through the pedicle, the superior articular process remaining attached to the body, and the inferior articular process to the lamina. This is shown particularly well in the *x*-ray picture.

This patient had a number of accidents and injuries, any one of which might have caused a tear of the fibrous tissue uniting the segments of the neural arch of the fifth lumbar, predisposing to the dislocation. The patient himself noticed that the "hollow" in his back increased after heavy lifting. As the deformity is getting worse the patient was advised to have a spine fusion. He has, however, refused consent and has continued to work despite his evident disability.

Case III. Mrs. R. G., thirty-eight years of age, came to my clinic at the Hospital for Joint Diseases on May 8, 1929, complaining of pain in the lower part of her back. The pain radiated down the back of both thighs and the lateral surfaces of the legs. The pain is most marked in the morning. It disappears by noon, after which she can walk, work and attend to all of her household duties. The symptoms came on about six years ago without any known injury. The patient believes her backache due to her many pregnancies. Although she is only thirty-eight years old she has given birth to 9 children and has had several miscarriages.

The examination of this patient is negative except for an increase in the lumbar hollow. The back is symmetrical. The spine is freely movable and the motions are painless. There is no hollow above the sacrum and no sensitiveness to pressure. There is no disturbance in the reflexes of the motor or sensory functions. The lateral *x*-ray picture (Fig. 7) shows an anterior subluxation of the last lumbar vertebra. The anterior border of the body of the last lumbar is at least one-quarter of an inch in front of that of the sacrum. The neural arch of the last lumbar is in its normal position, but there is a marked elongation of the laminae of the last lumbar.

This case appears to be one of a purely congenital spondylolisthesis resulting from an elongation of the laminae of the last lumbar vertebra. The numerous pregnancies have probably had no effect on the bony structure of the lumbosacral area, but have caused a chronic sprain of the lumbosacral articulations, resulting in backache. The patient has been relieved by wearing a corset and, for the present, needs no operative fixation.

Case IV. Mrs. J. K., thirty-two years old,

consulted me on November 5, 1929, for pain in the lower part of her back and a burning sensation in the right thigh. This patient had

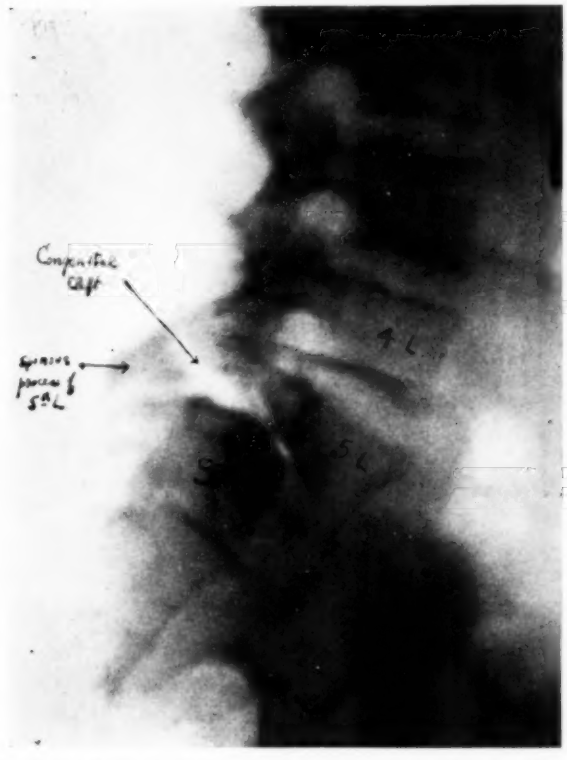

Fig. 6. Case II. Lateral roentgenogram shows defect in laminae with wide separation of body and spinous process. Note convexity of superior surface of sacrum, favoring dislocation of fifth lumbar.

not had any backache until last summer, when she first noticed some discomfort in the lumbar area. At this time she was in a camp, and, as she had been very active, swimming, diving, playing tennis and engaging in other outdoor sports rather vigorously, she attributed her backache to excessive exercise. She did not recall any severe injury, and did not believe that the exercise had brought on the backache as she had always been athletic and frequently indulged in considerable outdoor activity. However, the pain increased and finally became so severe that she could not walk. A rest of several weeks improved her immensely, but the backache has continued in mild form. When she returned to the city in the fall she related her experiences to her brother, who is a physician. He examined her and found a deformity of the spine. Neither she nor her brother had noticed the deformity previously and did not know how long it had been in existence.

My examination showed a well-developed individual who walked without a limp, difficulty, pain or effort. There was a very distinct hollow in the middle of the back above the sacrum (Fig. 8). What I thought was the

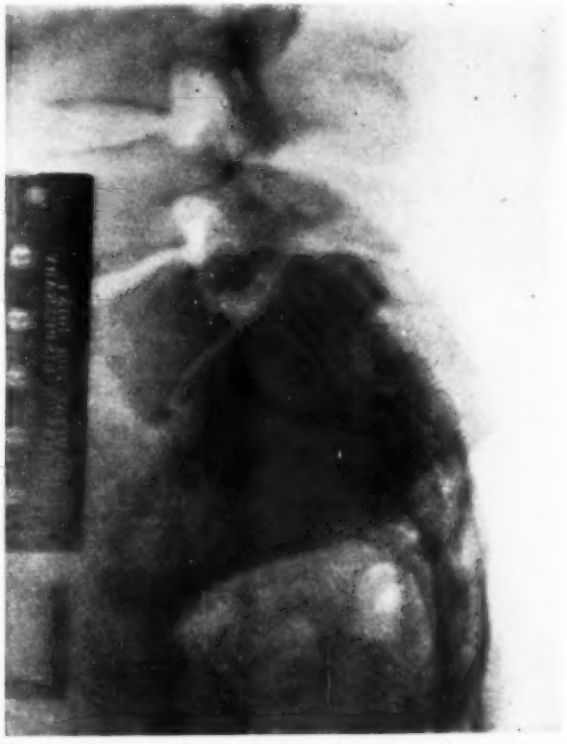

Fig. 7. Case III. Lateral view showing subluxation of fifth lumbar vertebra. Laminae of fifth lumbar are elongated.

spinous process of the first sacral segment, but proved from the *x*-ray picture to be that of the last lumbar, was very prominent. Flexion of the spine was markedly restricted; the other motions were only moderately limited. There was no sensitiveness to pressure over any part of the back. There was no change in the sensory or motor functions, but there was a distinct exaggeration of the reflexes and a tendency to ankle clonus on the left side.

The *x*-ray picture (Fig. 9) showed a marked forward subluxation of the fifth lumbar on the sacrum. The spinous process of the fifth lumbar is in normal relation with that of the sacrum. The laminae of the fifth lumbar are, as in the last case, elongated, but show no cleft or defect. The laminae of the other lumbar vertebrae are normal in size. The body of the last lumbar is displaced forward so that half of it is in front of the sacrum.

In this patient, as in the last, I believe that the deformity is congenital and due to abnormally long laminae with resultant forward slipping of the body of the last lumbar vertebra.

The 4 cases here reported show 2 types of lesion: (1) a defect or split in the pedicles of the last lumbar vertebra with separation

FIG. 8. Case IV. Side view showing prominence of sacrum and hollow above sacrum.

of the articular facets which are held together only by connective tissue; (2) an elongation of the laminae of the last lumbar vertebra. As the spinous process of the last lumbar remains in normal relation with that of the sacrum, its body is naturally displaced in front of that of the sacrum. In all the cases trauma was an important factor. In the first 2 cases the injury caused a tear of the connective and ligamentous tissues uniting the articular processes and made it possible for the force of gravity and weight bearing to produce a forward dislocation of the vertebral body. In the third case the injury incident to the numerous and frequently repeated pregnancies, and in the fourth case the injury done by strenuous gymnastic exercises caused a strain of the lumbosacral articulation and resultant backache. In the first

FIG. 9. Case IV. Lateral roentgenogram. Shows marked displacement of fifth lumbar and elongation of laminae without any break in continuity.

type of lesion, in which there is a break in the bony wall of the neural arch, a spine fusion is imperative to relieve existing symptoms and to prevent future increase of the dislocation. In the second group, one should always first attempt to relieve the symptoms by some form of external spinal support, and only in case of failing to help the patient should one resort to an operative fixation of the spine.

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DISCUSSION

Dr. Edwin Pyle: Of the cases that I have operated upon or seen operated on not one has failed to show defects in the laminae. In many of the *x*-ray examinations before and after, it was impossible to see the defect. I believe they all have it; but if one part of the lamina is superimposed on the other so that the *x*-rays do not pass directly through the defect. I do not think it will show on the *x*-ray plate.

The prominence which is felt just below the exaggerated lumbar lordosis is not the superior surface of the sacrum but the spinous process of the fifth lumbar vertebra.

Dr. Mather Cleveland: The lumbosacral junction is subject to a great many variations, and of the less frequent variations that we see is this: spondylolisthesis. We not infrequently see cases with rather severe backache and with no spondylolisthesis where there is a failure of fusion between the laminae and pedicles of the fifth lumbar vertebra; in other words, due to an unstable lumbosacral junction. It so happens that in the Anatomical Department of Columbia a skeleton very beautifully illustrates the point that Dr. Kleinberg has mentioned, this failure of fusion between the laminae and pedicles of the fifth lumbar vertebra. This represents a potential spondylolisthesis, but not an actual one. I think that many individuals who have this condition are all set up for spondylolisthesis but may never develop it.

Dr. Armitage Whitman: I have been much interested in Dr. Kleinberg's paper and Dr. Cleveland's remarks, because at the May, 1924 meeting of the American Orthopedic Association I reported a group of 5 cases with a description of the history, clinical and *x*-ray findings, and the surgical anatomy based on the operation performed on 1 case. They were all cases of great exaggeration of the lumbosacral angle. In 2 cases there was demonstrable forward displacement of the fifth lumbar on the first sacral vertebra. In the others there was none, but the predisposition to displacement was self-evident. I described the condition under the term "Prespondylolisthesis."* It gives me pleasure to report that the only case of a patient in the group operated upon in which a combined fusion and tibial graft was performed is at the end of seven years completely well, married, and engaging freely in all forms of physical activity.

Dr. Kleinberg, *closing:* I have but one word to add. I have been very much interested to find out the exact incidence of spondylolisthesis. I have here some figures which Dr. Pomeranz, radiographer of the Hospital for Joint Diseases, was kind enough to give me. In the year 1929–30 1655 spines were *x*-rayed at the Hospital for Joint Diseases. In this group 4 instances of spondylolisthesis were found. These figures will indicate that the incidence of spondylolisthesis amongst pathological spines is about one-fourth of 1 per cent.

* *J. Bone & Joint Surg.* October, 1924.

CHEMISTRY AND PHYSIOLOGY OF CALCIFICATION*

JOHN P. PETERS, M.D.

NEW HAVEN, CONN.

TO those in the audience who may be chemists I should like to speak as a physiologist; to those who may be physiologists I should prefer to claim the privileges of a chemist; those who, like myself, are neither physiologist nor chemist, but interested students of both sciences, will sympathize with me if I temper the austerity of chemistry with a touch of physiology in an attempt to escape the dilemma into which the exponents of purely chemical or purely physiological points of view have been thrown. With such a pragmatic attitude it seems possible at the present time, while admitting ignorance of the exact nature of the forces behind certain of the phenomena concerned and the existence of large gaps in our knowledge, to build up a useful and coherent picture of the nature of the process of normal calcification, or bone formation, and the factors influencing it.

In simple terms calcified bone may be considered to be a solid precipitate of calcium salts in contact with a solution containing the same salts. Bone is composed chiefly of calcium phosphate and calcium carbonate. From a chemical point of view it is possible and simpler for many reasons to discuss the problem as if the bone were a simple deposit of calcium phosphate. As evidence that such a view is substantially correct certain simple experiments may be cited: First, the fact that bone is decalcified in vitro in solutions in which its salts are soluble; second, the fact that calcium salts are deposited in an orderly structure resembling normal bone formation in growing bone suspended in vitro in normal serum. In a system consisting of a solid salt in contact with a solution of that salt, under any given conditions an equilibrium will be reached when the solution is saturated with the salt. At this point no more is precipitated out or, in more dynamic terms, the quantity which is at any time dissolved is equalled by the quantity which is at the same time precipitated. Any condition which increases the solubility of the salt will cause part of the precipitate to dissolve; anything which reduces solubility will cause precipitation of some of the dissolved salt. Heat, cold, change of reaction are factors that commonly change the solubilities of salts and therefore influence precipitation.

Another important factor is the concentration of the individual components of the salt in question, the solubility product of mass law fame. In a saturated solution of sodium chloride containing precipitated sodium chloride, under any given environmental conditions, the solubility product law says that the product of the concentrations of sodium and chloride will remain constant. The addition to the solution of either sodium or chloride will cause precipitation of sodium chloride. Therefore, calcification must depend not only on the amount of calcium but also on the amount of inorganic phosphate in the solution in contact with bone. An increase of either component will increase precipitation (that is, calcification); a diminution of either component will further solution (that is, cause calcification). The simple fact that the deposition of calcium phosphate could not depend on calcium alone would hardly seem to require such complex scientific explanation. It seems almost as obvious as the fact that one can not make ham and eggs out of ham. Nevertheless, the literature is full of figures attempting to relate calcification to serum calcium or, more rarely, to serum phosphate, alone; and surprised, sometimes almost petulant remonstrances at the uselessness of chemistry when no clear correlations are found.

In spite of all my preparatory apologetic defenses I dare not set sail from the quiet

* Presented before the Section of Orthopedic Surgery, New York Academy of Medicine, April 18, 1930.

waters of the test tube into the more stormy biological deeps without serious provision against the chemical pirates who may be lying in wait for me. Chemically there is some question concerning the state of saturation of the serum with calcium phosphate and the proper manner of calculating solubility products. Some claim that bone is composed of tricalcium phosphate and that the solubility product must be calculated as the cube of the calcium times the square of the phosphate; others insist that bone is composed of acid calcium phosphate and the solubility product should be estimated merely as calcium times phosphate. The question is whether ham and eggs are two pieces of ham and 3 eggs or a slice of ham to each egg. This evening I shall let the two parties fight between them, content if only I can sail around them with both ham and eggs in any reasonable proportions.

For the purposes of the present discussion, then, I shall make the reasonable assumption that serum is a solution in which calcium and inorganic phosphate exist in such concentrations that the solution is always nearly or quite saturated with calcium phosphate. If there is still objection to this statement on the ground that it cannot be mathematically and chemically substantiated, I shall fall back on my physiological privileges and say it is biologically or effectively saturated in the sense that it acts qualitatively like a saturated solution as far as calcification is concerned. Some may object to my speaking of blood serum as the fluid that bathes bone. To these I answer that it is the transportation system on which any fluid more contiguous to bone must depend for its supply of calcium and phosphate and with which such a fluid must presumably be in equilibrium. Moreover, experiments of Arnold and Mendel have shown that the composition of lymph mirrors that of serum exactly as far as calcium and phosphorus are concerned.

Even such a defensive phrase as "biologically saturated" demands a word of explanation. In a pure solution of salts having a composition such as that of serum it is impossible to dissolve as much calcium phosphate as is normally held in serum. If protein is added to such a solution more calcium will dissolve. In serum and other calcium-containing body fluids the calcium concentration varies directly with the amount of protein in the fluid. Thus there is less calcium in lymph, transudates and spinal fluid, which contain little protein, than there is in serum. This extra dissolved calcium which, chiefly through experiments of Robert Loeb,[1] we have reason to believe exists combined with protein as calcium proteinate, appears to play little or no part in the process of calcification. One might say that it is unavailable for formation of calcium phosphate or, to return to our homely simile, this ham cannot be used to make ham and eggs because it has already been made into ham sausage.

From the standpoint of disease it is important to recognize this inactive portion of calcium. In certain types of nephritis, especially the picture spoken of as nephrosis, the serum calcium may fall to extremely low levels without the appearance of tetany or any evidences of decalcification, phenomena that are recognized as signs of calcium deficiency. In these cases the reduction in calcium appears to affect chiefly the inactive fraction attached to the serum proteins which, in these conditions, are greatly reduced. Malnutrition is another condition in which serum proteins and calcium fall together. This may afford an explanation for the slightly lowered serum calcium of advanced tuberculosis to which some observers have tried to attach importance. In pregnancy, also, serum proteins are low and a slight calcium deficiency has been demonstrated. These deficiencies have no apparent bearing on calcification processes. Their practical significance lies chiefly in the fact that, if serum calcium figures are to be evaluated in relation to calcification the concentration of protein in the serum must

be taken into consideration. In fact it is doubtful whether one can safely interpret serum calcium figures unless both protein and phosphate concentrations are also known. Therefore, it is safer routine practice to determine all three when clinical information is desired.

Even allowing for the inactive protein-bound calcium, serum holds in solution more calcium than would an artificial solution of the same composition. One must, then, recognize a third fraction of calcium which is held in solution by virtue of certain peculiar biological properties of the body media. This fraction, moreover, appears to be physiologically active and concerned with the processes of calcification. The factor which can be most clearly recognized as contributing this extra calcium dissolving power to serum is the internal secretion or hormone of the parathyroid gland.[2,3]

There are, then, three separate fractions of calcium in the serum and body fluids to be functionally distinguished. These may be spoken of as chemically dissolved calcium, biologically dissolved calcium, and calcium combined with protein. The first two, chemically and biologically dissolved, are in equilibrium with phosphate and concerned with calcification and bone formation; the protein fraction is not.

With only these premises why should calcium phosphate be deposited in one place rather than another? The answer to this question can be approached from either the negative or the positive side. From the negative side certain facts of interest appear. Calcium cannot precipitate in the red blood cells, for example, because these cells contain no calcium. Muscle cells appear to contain very little calcium and large amounts of protein. For the preservation both of our theory and of these cells this is fortunate, because muscle cells contain, at times, such large quantities of phosphate that calcium precipitation within the cells would inevitably occur if calcium were present in high concentration. From the positive side we are left with the fact, first established by Shipley and Kramer,[4] that growing bone suspended in normal serum undergoes active calcification in vitro. This calcification is dependent upon some vital property because it is prevented by protoplasmic poisons. Other tissues treated in the same manner do not become calcified. Such a phenomenon could be easily explained if it could be proved that by some local chemical reaction conditions in the bone were made more favorable for calcium phosphate precipitation. This Kay and Robison,[5] in England, believe they have demonstrated. They have secured from ossification centers of growing bone extracts which break down certain organic phosphorus compounds with the formation of inorganic phosphate. You can see that this would cause the local accumulation of an unusual amount of phosphate, the product of calcium and phosphate would exceed the solubility product and calcium phosphate would be precipitated. Although these experiments are not conclusive and require confirmation, they afford a plausible explanation for bone formation and indicate the type of reaction that may prove to be responsible for calcification processes.

Before proceeding to a discussion of the absorption and excretion of calcium and the influences which favor and those which retard calcification, I should like to emphasize again the fact that calcium and phosphate are mutually dependent. Bone cannot be laid down from calcium alone. Deficiency of either calcium or phosphate interferes with or retards calcification. Furthermore, in the serum, because it is a saturated solution, concentrations of calcium and phosphate are more or less reciprocally related. Binger[6] was the first to demonstrate that administration of sufficient phosphate salts to increase phosphate in the serum causes serum calcium to fall and may, thereby, induce tetany. Since then the reciprocal relations between the two ions has been repeatedly demonstrated. It follows that one may have

normal serum calcium with deficient calcification if phosphate is greatly diminished, and normal calcification with deficient serum calcium if phosphate is greatly elevated. The first condition is the one usually encountered in the active stages of rickets, the second is not uncommonly observed in healing rickets.

Thus far the internal environment has been considered as an isolated system. However, it is not independent of the external world. In the first place calcium and phosphate excretion do not cease when the supply is cut off. The organism is, in this case, forced to subsist upon its own internal repositories, the bones, as a source of calcium. There is a certain amount of phosphorus outside of the bones on which the body may call in case of need. This is found in organic combination in proteins, lecithin and other phospholipids, and in organic phosphoric acid esters, all of which occur as structural units of protoplasm. This, Shohl[7] has shown, probably explains the mysterious healing of rickets that is brought about in animals by starvation. However, such endogenous phosphate stores become available for calcification only at the expense of other important structures of the body; and there are no such endogenous calcium stores.

Figure 1, representing schematically the metabolism of calcium and the influences which affect normal calcification or calcium deposits, may aid some in an understanding of the subsequent discussion.

The absorption, from the alimentary tract, of calcium and phosphorus depends first of all, of course, upon the adequacy of the supply of these materials, secondly upon their solubility. Insoluble material cannot be absorbed from the gut. The main determinants of solubility are the reaction of the alimentary contents and the quantities of fatty acids unabsorbed. Alkalinization diminishes the absorption of calcium by causing the formation of insoluble calcium carbonate and phosphate. Acid promotes absorption of calcium by forming more soluble acid salts. It is for this reason that calcium carbonate is so much less efficient than calcium chloride as a means of conveying calcium into the body. By the same token gastric achlorhydria may interfere with calcification. Calcium soaps, salts of fatty acids, are extremely insoluble. Therefore, failure to absorb fat from the intestine is attended by improper calcium absorption. So serious may this become that a condition resembling osteomalacia has been known to develop as the result of long-standing fatty diarrhea.

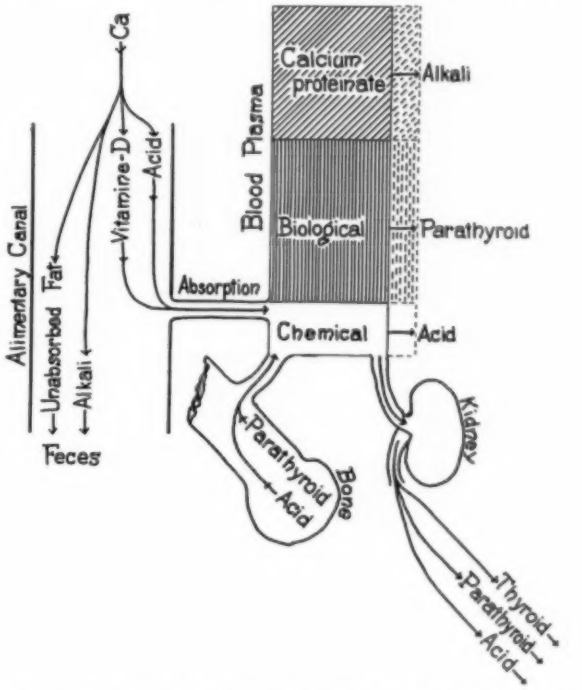

Fig. 1. A schematic representation of the chief factors that affect normal calcification or calcium deposits.

The tube on the left represents the alimentary canal, which is connected with the right-hand column, the blood serum, by a passage marked "absorption." The serum column, surrounded and subdivided by solid lines, shows the relative proportions in which the three types of calcium are found in normal serum. The extensions of this column to the right, surrounded and subdivided by broken lines, represent increases of one or other calcium fraction which may be brought about by influences which increase the solubility of these calcium fractions. The chief influences of this kind which affect each fraction are named opposite arrows, which also indicate the direction of their action. Below are seen outlets to the bones and, through the kidneys, to the urine. The factors which influence absorption and excretion of calcium and its deposition in the bones are represented by the named arrows.

There is one more factor concerned with the intentional absorption of calcium which gains its effects by a mechanism that is still obscure. This is the antirachitic vitamin D, by which I mean the active principle of cod liver oil, ergosterol, activated by ultraviolet irradiation. The primary and perhaps sole effect of this vitamin appears to be to increase calcium and phosphorus absorption from the alimentary tract. Zucker[8] suggested that it gained its effects chiefly by rendering the contents of the gut more acid, but recent work of Shohl[9] and others has made this theory untenable, without offering an alternative explanation for the effect of vitamin D on calcium absorption.

Increasing the absorption of calcium and phosphorus, other things being equal, will promote calcification. Therefore, an adequate supply of vitamin D, normal fat absorption and the maintenance of a relatively acid reaction in the alimentary contents may be looked upon as calcifying procedures, provided adequate amounts of calcium and phosphorus are given in the diet.

If the blood-bone system is considered as a unit, the direction of the flow of calcium salts is found to depend upon the supply of calcium and phosphorus and the solubility of these salts in the serum. The factors which chiefly affect solubility are acid, alkali and the parathyroid hormone. Acid, in the serum as in the stools, increases the solubility of calcium, affecting what I have called the chemically dissolved fraction. Therefore, acidifying measures will tend to decalcify bone. It is on this basis that ammonium chloride is used in the treatment of lead poisoning to promote the elimination of lead from the bones. (We have had under observation for some time, in our clinic, a girl who has, by means of a persistent nephritic acidosis, developed a condition resembling osteomalacia.) Alkalinization, on the other hand, diminishes the solubility of calcium salts and, therefore, tends to conserve bone. It is evident that acid, one of the factors which promotes absorption from the gut and thus favors calcification, tends to defeat itself by increasing the solution of calcium salts from bone. Which of these effects will predominate must depend on their relative magnitude. If the supply of calcium is made large enough acidification is an efficient means of promoting calcification and has been employed to advantage in the treatment of rickets.

The other chief factor which appears to influence the solubility of calcium phosphate in the serum is the parathyroid hormone, which affects the biologically soluble fraction. Hyperparathyroidism or parathyroid extract increases the concentration of calcium in the serum by dissolving calcium from bone. Every few months adds one or more to the recognized cases with this condition. The symptom complex has been clearly defined. It consists of: increased calcium in the serum with diminished phosphate; excessive excretion of calcium and phosphorus; osteoporosis, sometimes with multiple cystic tumors of the bones; muscular weakness and hypotonia.

Hypoparathyroidism has the opposite effect: diminution of the serum calcium with increase of phosphate; lessened excretion of calcium and phosphorus; muscular irritability and tetany. Thickening of bone may not result because of inability to eat and to thus maintain an adequate supply of calcium and phosphorus. The symptom complex, tetany, seems to be referable specifically to the low serum calcium concentration.

There is some evidence of an uncertain nature that vitamin D may have a direct effect on the maintenance of the level of calcium and phosphorus in the serum. By the administration of excessive doses of irradiated ergosterol serum calcium may be pushed up to extremely high levels. However, unlike that of hyperparathyroidism, the hypercalcemia due to vitamin D is not associated with decalcification; but with augmented calcification, which may even affect tissues other than bone.

Finally one must look to the kidneys as a channel for wastage of calcium. The excretion of calcium is not independent of the level of calcium in the serum and is increased by factors that tend to raise the serum calcium. Chief of these are, of course, acidification and the parathyroid hormone.

One other factor must also be recognized in this connection, thyroxin or the thyroid hormone. Aub has shown that patients with hyperthyroidism waste calcium and, consequently develop demonstrable rarefaction of the bones. Thyroxin has the same effect, while hypothyroidism, whether spontaneous or induced, is attended by retention of calcium and phosphorus and increased deposition of calcium salts in bone.

Theoretically the possibility of conditions in which there is disturbance of calcification due to some inherent defect in the biological factor in bone itself, must be recognized. If Kay and Robison's theory should prove correct one would think of this as excessive or deficient activity of the phosphoesterase. No definite proof of the existence of such conditions has, however, as yet been adduced. Shipley found that in vitro calcification proceeded normally in rachitic bone suspended in normal serum, but was defective in normal bone suspended in rachitic serum. The deficiency in this case lies in the medium, not in the bone.

In summary one may state that the problem of normal calcification can be correlated closely with the concentrations and solubilities of calcium phosphate in biological media, although it is still impossible to formulate a quantitative statement of these correlations in simple mass law equations that will satisfy the chemist. At least three fundamental factors in calcification can still be described only indefinitely as vital properties, although the present intensive investigation of the problem bids fair to throw some light on the nature of these properties. These three factors are: 1. the power of vitamin D to further alimentary absorption of calcium phosphate; 2. the factors, of which parathyroid is one, which permit serum and other body fluids to hold in solution such a high concentration of calcium; 3. the factor which depresses solubility, thereby producing precipitation, in regions of normal calcification.

Calcification cannot be correlated with the levels of calcium in the serum. One fraction of the serum calcium, which depends on the protein content of the serum, apparently plays no part in calcification. Even the non-protein active calcium is not in itself a criterion of calcification; this depends on the product of calcium and inorganic phosphorus. These two elements, other things being equal, vary reciprocally. Of the active calcium two fractions can be recognized, the chemically soluble and the biologically soluble calcium. Anything which increases the solubility of active calcium in the serum tends to dissolve calcium from the bones. The chief decalcifying measures of this class are acidification, which affects the chemically soluble fraction, and excess of the parathyroid hormone, which affects biological solubility. Osteoporosis has been recognized as the result of hyperparathyroidism and, in at least one case, apparently as the result of long-standing acidosis.

The bones are used as a store of available calcium and phosphorus when the exogenous supply is deficient. Therefore, proper calcification depends on the provision of an adequate supply of both calcium and phosphorus and the maintenance of favorable conditions for their absorption in the alimentary canal. Such favorable conditions are efficient digestion and absorption of fat, the maintenance of a relatively acid medium and the presence of a sufficient supply of both components of vitamin D, ergosterol and ultraviolet light. Rickets and true osteomalacia both appear to be deficiency diseases due to insufficient supply of calcium and phosphorus.

Finally decalcification may occur in the

face of an otherwise sufficient supply of calcium and phosphorus if urinary excretion of these substances is greatly accelerated. The chief factors which cause accelerated urinary elimination are acidification and the internal secretion of the thyroid gland.

The state of the process of calcification at any one time will be a resultant of the effects of all these individual factors; and only by the application of discriminating judgment to the analysis of an individual case can diagnosis and therapy be intelligently directed.

DISCUSSION

Dr. Frederic W. Bancroft: I have been interested in the cellular side of bone repair. As you know, it is easy to produce extraskeletal bone experimentally. If one ligates the renal vessel and wraps omentum about the kidney, at the end of a month bone and calcification are seen in the parenchyma of the kidney. Bone occurs where there are living cells and calcification in the necrotic areas. The mineral ash of calcification and ossification is the same. You may scrape the aorta of the rabbit and paint it with silver nitrate, and bone will occur in the adventitia. It occurs in the bite of the ligature. Pathologically bone occurs in almost every organ of the body. Neuhof, in experimenting with fascia lata transplants to fill a defect in the bladder, found that bone almost universally occurred in the fascia lata transplants. Obviously if one is to produce a theory of bone formation it must account for extraskeletal, experimental, and pathological bone, as well as for skeletal bone. If one studies the microscopic sections of bone repair following fractures, and such sections are studied from three days after the injury until two or three weeks, it will be seen that following trauma hemorrhage occurs; then one sees wandering fibroblasts and beginning organization of connective tissue. About four days following the fracture beginning ossification is seen in the avascular areas of the newly-formed granulation tissue. One sees a blood vessel, and, surrounding this, areolar tissue and at the periphery new bone. This ossification does not appear microscopically to be a result of the secretory phenomena of a specific cell: it appears as if the wandering connective tissue cells were caught in a deposit of calcium salts. This appearance compares very well with Dr. Peters' suggestion that the calcium salts are deposited due to some change in the hydrogen ion content. I am glad to know Dr. Peters stresses the fact that the calcium in the skeleton is in a state of flux and may be drawn from the body in case of emergency. Much harm has been done by our conception of bone as the hardened inert mass one sees hanging up in the laboratory as a prepared skeleton. Bone is a living structure and is constantly changing, not only in shape but in concentration, to meet the daily demands of the human organism.

Dr. R. F. Loeb: From what Dr. Peters said, it is clear that great strides have been made in our understanding of the problem of normal calcification, but it is also apparent that we have not yet reached the end of the problem. From the point of view of the local conditions in the tissues, it is apparent that we are just beginning to scratch the surface of a very difficult investigative task. Like Dr. Bancroft, I am neither a chemist nor a physiologist and do not wish to enter upon the question of the local mechanisms existing within the bone which are important in calcification; I do, however, wish to emphasize what Dr. Peters has said, perhaps expressing it as the evaluation of the problem of calcification in a given patient. Dr. Peters has emphasized the fact that the blood calcium determination in itself is of little value. First of all this is true because in the presence of a high blood calcium we have no way of knowing from this determination alone whether calcium is going to or coming from the bone. Hence any attempt to judge a process of calcification from that point of view alone is ridiculous. In some cases the relationship of active calcium and of phosphorus may be adequate in the blood in the presence of a low calcium concentration, this being true, as Dr. Peters has pointed out, when the protein content of the serum is low. In spite of the proper consideration of the protein calcium and the protein calcification in the serum, Dr. Peters has pointed out that decalcification or abnormally great calcification may be proceeding. This point has been made clear from the studies of Aub and Bauer in their work on hyperthyroidism in which decalcification may be marked and yet blood concentration of the factors involved in calcification may be normal.

From the clinician's point of view the time is certainly coming when our being satisfied with such vague terms as osteoporosis or osteomalacia may no longer satisfy us and we must begin to consider these conditions from the point of view of the factors from which they develop. For instance, as Dr. Peters has pointed out, in thyroid disease with normal levels of calcium and phosphorus in the blood we have an increased loss of calcium through the kidneys, perhaps as a result of a lowered threshold. On a very acid diet decalcification is brought about again by increasing solubilities of calcium phosphate in the blood, and in certain cases of faulty fat absorption from the intestine rarefaction of bone may result from inadequate absorption of calcium. Hence in any case of abnormal calcification it seems important that an accurate study of the relation of calcium intake and output should be made.

Finally, I should like to emphasize the danger of the promiscuous use of two new weapons introduced into clinicians' hands for the so-called treatment of osteoporosis, or delayed bone union. Parathyroid extract for a time was used in the treatment of some of these conditions, but we now know that its employment is absolutely contraindicated as the increased calcium in the blood resulting from injections of this hormone is derived from bone and is in no way related to increased laying down of the bone. With irradiated ergosterol we have a similar situation; it appears to increase absorption of calcium and phosphorus from the intestine, thereby increasing the concentration of calcium in the blood and increasing calcification of the bone. However, after exceeding a certain level in the dosage of ergosterol, calcification is no longer increased, but actually decalcification begins, also with an elevated calcium concentration of the blood, as has been shown recently by Shohl and others. It might be well for the time being to study the calcium balance in those cases in which irradiated ergosterol is being used to promote calcification.

Dr. Clay Ray Murray: My interest in this subject lies in its application, if any, to the question of delayed or non-union in fractures, in the bearing which the biochemistry of the blood serum has on fracture healing.

As clinicians, we all know that if a patient comes to us with a fractured neck of the femur, intracapsular, we immediately begin to wonder whether that fracture will show bony union, fibrous union, or actual absorption of the neck of the femur. If a patient comes in with an intertrochanteric fracture, an inch and a half further down the bone, we are so sure of bony union that it has become a byword that this latter type of fracture heals by bony union *despite* treatment. This viewpoint, based on empirical clinical findings, holds regardless of the age of the patient, his metabolic state, his general health, specific disease, or any other clinical factors. Again, if a patient shows a fracture of the tibia, at the junction of the lower and middle thirds, one counts on a slow union, with a chance of non-union. The same is true of fractures in the lower portion of the middle third of the humerus. I remember a patient who fell from a building and sustained a double fracture of both tibiae, one at the juncture of the upper and middle thirds and one at the juncture of the lower and middle thirds in each leg. Both legs were treated identically by pin traction, with excellent rapid reduction, and early physiotherapy. The upper fracture in each leg healed by bony union in average time; the lower fracture on one side developed a delayed union requiring nineteen weeks for bony healing, and on the other side the lower fracture resulted in a non-union requiring operation.

Actually, clinical observation leads to the conclusion that delayed and non-union, when fracture treatment is competent, is a problem of the fracture site, and not of the individual involved. At certain sites one frequently sees delayed and non-union under the best of treatment. At other sites, one never sees it under proper treatment.

Clinically also, the very cases which show a generalized calcium and phosphorus metabolic disturbance show a normal fracture healing, except when the places involved are the very sites which show delayed and non-union in the metabolically normal individual. Particularly, I cite rickets and osteomalacia cases. They heal their fractures normally. At the Presbyterian Hospital we now have a patient with osteomalacia who has had a low serum calcium, a serum phosphorus as low as 1.2, and under careful and prolonged metabolic study a negative calcium balance. She sustained a pathological fracture of the lower femur, which shows by *x*-rays a solid bony healing with no delay in time.

Another case of clinical interest from this

viewpoint, and this situation is frequently found, is that of a patient having a fractured neck of the femur recently seen at the Presbyterian Hospital, in whom the neck of the femur absorbed practically completely within eight weeks, and *simultaneously* there was going on *extensive* calcification of the joint capsule.

Again, I have never been able to observe any clinical effect on delayed or non-union from the administration of medications designed to correct possible defects in calcium and phosphorus metabolism. I have utilized and observed the effects of calcium by mouth, cod liver oil, thyroid, parathyroid hormone, mercury quartz vapor light, irradiated ergosterol, and the various vitamin foods. In no cases has there been clinical evidence of any effect. The blood phosphorus and calcium has been recorded in these cases, though it must be acknowledged that without accurate control of balances they mean little if anything. The blood findings have no relation to the occurrence of delayed or non-union.

These varied findings have made me feel for some time that the story of delayed and non-union in fractures was a purely local one, that the biochemical changes which occurred, resulting in the deposition of calcium, were local in the tissue fluids, and not dependent on the amount or state of the calcium or phosphorus in the blood serum. In an experimental series, mention of which has been made in the literature and the full data of which is shortly to be published, a 2½ cm. piece of dog's radius was resected with its periosteum, creating a 2½ in. gap in the bone. If the resected piece were cut into small chips and dropped back in the gap, solid bony filling of the gap would occur. If the fragments were first boiled, destroying their vitality, solid bony union would occur just the same. If they were first decalcified, no bony union would occur. If the fragments were discarded and the gap left empty, no bony union would occur. But if the fragments were discarded and the gap filled with calcium carbonate and calcium triple phosphate, or with calcium carbonate and calcium phosphate, *bony union* would occur. In this series of animals, under the given conditions, certainly the occurrence of bony union depended on the presence or absence *locally* of calcium, regardless of the chemistry of blood serum. All these animals were on the same diet, and apparently normal, giving no evidence of metabolic disturbances. All were adult animals. The bone chips as a local calcium source in fractures are represented by the bone killed by the fracturing violence and pathology. The autolysis and demineralization of this bone can be clearly demonstrated, as can the fact that the tissues about a fracture site contain a really tremendous calcium concentration.

I am convinced by both chemical evidence and the experimental findings in toto in this field, that the ossification of a healing fracture is dependent upon local factors at the fracture site, and that even if we grant the exact mechanism of calcium deposition which Dr. Peters describes, the factors *in the blood serum* which he has mentioned have absolutely no bearing on the clinical union or non-union at a given fracture site.

Dr. Fred Albee: I have published experimental work very similar to what Dr. Peters outlined,[1] with reference to checking up on putting fragments of bone in between the fragments where a section of bone had been removed.

I was induced to carry on the research at that time because of claims published that a new treatment had been discovered for pseudarthrosis in the human subject from experimental work upon animals. It was stated that it was found when a segment of an animal's long bone was resected and chipped with small fragments and placed back in the hiatus it came from, that the bone never failed to unite.

Feeling that an animal's bone will ordinarily unite under most any conditions, early in 1918, with the collaboration of Lieut. H. F. Morrison, I undertook to produce a pseudarthrosis in a rabbit's leg and failed. Segments were resected from various long bones and put back whole, in different sized pieces; no bone was put back at all; the animals' limbs were exposed to heavy doses of *x*-ray; they were carefully splinted, and no splints were supplied whatsoever, but we did not succeed in producing one pseudarthrosis. Every bone united.

Solutions of triple phosphates were also injected into the region of the callus of a broken rabbit's bones. A comparative *x*-ray study of these results and controls led to the conclusion that increased callus formation had been stimulated.

When, however, the same solution was

[1] *Am. J. M. Sc.*, 1928; *Ann. Surg.*

injected into cases of true clinical pseudarthrosis, no benefits were derived whatsoever. In a few cases the tissue infiltrated broke down, and the case was then still further complicated.

I therefore wish to emphasize the fact that deduction based upon observations in relation to fresh fractures in animals, or in the clinic, must be applied with the greatest caution and conservatism to the problem of the treatment of pseudarthrosis.

It is very difficult to draw conclusions from such a discussion as that presented by Dr. Peters, when it is applied to actual clinical cases, but I have been very much interested and enlightened by it.

Dr. Peters, *closing:* My paper was limited to normal calcification, a subject that has been studied objectively and quantitatively. As far as I know the subject of healing fractures has not been studied objectively and quantitatively in the same sense.

Some experiments are now being made in another department than my own at Yale, on the healing of fractures in animals, which indicate that metabolic factors have a distinct influence upon fracture repair; that one can demonstrate quantitatively the effect of factors that affect absorption, deposition and excretion of calcium. The experiments which Dr. Murray presented do not seem to show careful consideration of such general factors. Undoubtedly local factors do have an influence. Kay and Robinson have suggested as an explanation for this influence the activity of phosphoesterases which, by converting organic to inorganic phosphates, increase the solubility product and therefore promote precipitation of calcium phosphate. The existence of such phosphoesterases not only in bone, but also in other tissues, has been demonstrated not only by Kay and Robinson, but by investigators in Meyerhoff's laboratories. It is rather interesting that a phosphoesterase almost indistinguishable from that of bone has been demonstrated in the kidney. Calcium deposition may occur in other tissues than bone, especially when they have been subjected to injury. The kidney seems peculiarly susceptible. But the factors that promote such deposition have not been studied objectively or quantitatively.

There is some work on record to show that healing does go on even in the absence of exogenous supplies of material; it proceeds at the expense of other tissues in the body. I object to the idea that ham and eggs can be made without either ham or eggs. Undoubtedly healing in rachitic bone will occur. These are quantitative matters. In rickets people do not go without bone; the deposition is only retarded. The injured animal in some respects seems to act like the growing animal, favored by distinct conservative processes. This can be illustrated by an example from nitrogen metabolism, a subject in which I am especially interested. If a person becomes mal-nourished, conservative processes are immediately instituted by the organism as if for self-preservation. These mitigate malnutrition and promote repair. When a part is injured some especial attention seems to be given to that part and all the conservative powers of the body are enlisted in its favor.

The fact that local factors influence calcification is a reason why they should be studied, but it is no reason for denying the influence of general factors which, I believe, are demonstrably active.

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ELECTROSURGERY AS A HEMOSTATIC INSTRUMENT IN OPERATIONS UPON THE LIVER, KIDNEY AND SPLEEN*

HERMAN E. PEARSE, JR., M.D. AND GRANT E. WARD, M.D., F.A.C.S.

ROCHESTER, N. Y. BALTIMORE, MD.

THE full use of electrosurgery has not been realized. The experience of Clark,[1] Wyeth,[6] Kelly,[2] and others has demonstrated that this device is a valuable adjunct in the eradication of malignant disease. Electrosurgery has proved its worth in dealing with carcinoma, but it is considered that there are other uses for these currents that have not been adequately investigated. After reading a very graphic account by Keen of the difficulty of controlling hemorrhage in operations upon the liver, it was decided that electrosurgery might be used with profit on vascular, parenchymatous organs. Experiments conducted on the liver, kidneys and spleen showed that extensive operative procedures can be carried out with only moderate primary bleeding, no secondary hemorrhage and good repair.

The results of these experiments were presented before the American College of Physical Therapy in Chicago, November, 1927, and were mentioned in the discussion of a paper by Dr. H. A. Kelly[2b] but were never published. In the following year the study on the kidney was amplified by G. E. Ward and W. W. Scott and the results confirmed. The operative procedures were more extensive in these experiments and two instances of secondary hemorrhage were recorded, apparently following infection.

Subsequently, McLean[3] described the healing of electrosurgical wounds, and Scott[4] reported on the advantage of the clinical use of the current on the kidney. We have used it clinically on the liver for biopsy, resecting tumor nodules and opening cysts, and dissecting the gall-bladder from the liver.

Since the data obtained from the original experiments influenced to some extent what has subsequently been done in the field, it was considered advisable to place them on record.

METHODS

Dogs were used as the experimental animals. All operative procedures were conducted under ether anesthesia after preliminary medication of morphia, ¼ grain. Strict surgical asepsis was observed and the animals allowed to survive.

Operations on the Kidney. The procedure consisted in excising a wedge-shaped elliptical segment, about 8 mm. wide and from 4 to 5 cm. long, from the cortex of the kidney, the apex of the wedge extending down into the pelvis. This is shown by Figure 1. The defect was closed in the usual manner by Halsted mattress sutures of silk. Since one object of the investigation was to determine the amount of primary bleeding, no clamp was placed on the pedicle vessels. In this manner one kidney was operated on electrosurgically and the other with a scalpel, giving comparison of the two instruments in the same animal. Bilateral nephrotomy through a midline abdominal incision is possible in the dog as the kidneys are movable and can readily be delivered. The animals were sacrificed at intervals and the appearance of the organs noted and photographed. As an additional control, histological specimens were taken from the scar in the two kidneys. A rough estimate of the hemorrhage from each kidney was made by counting the number of sponges soiled with blood. Twelve dogs were so operated upon and sacrificed at intervals of from twenty-four hours to eight weeks.

Other kidney experiments were carried

* From The Surgical Hunterian Laboratory, Johns Hopkins Medical School. Submitted for publication October 6, 1930.

out on a few more animals. A broad, disc-shaped portion of the cortex, 2 × 4 cm. in size, was removed with the current and the kidney replaced without suture. In other animals, formaldehyde solution was applied to the coagulated surface to determine its effect upon secondary hemorrhage. Finally an entire pole or half the kidney was removed with a tonsil snare carrying the current, and the kidney was replaced without suture or packing. These experiments could not be compared with similar procedures done with the scalpel since excessive hemorrhage would result from the cut surface.

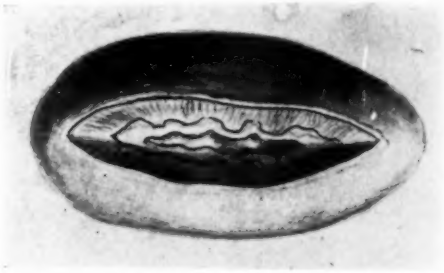

Fig. 1. Kidney, after removal of elliptical wedge shaped segment down to pelvis.

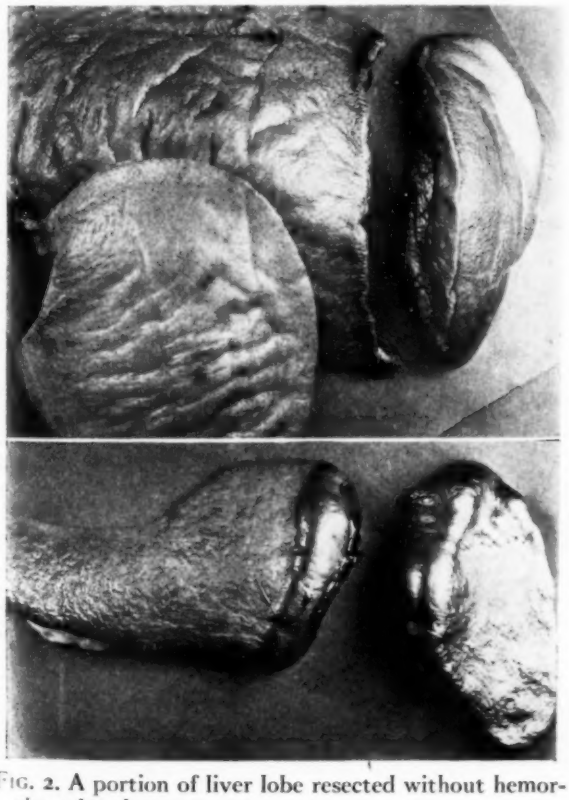

Fig. 2. A portion of liver lobe resected without hemorrhage by electrosurgery.

Fig. 3. Pole of spleen removed with tonsil snare and diathermy. Note excessive coagulation.

Fig. 4. A comparison of wounds made by electrosurgery and scalpel in kidney (twenty-four hours after operation).

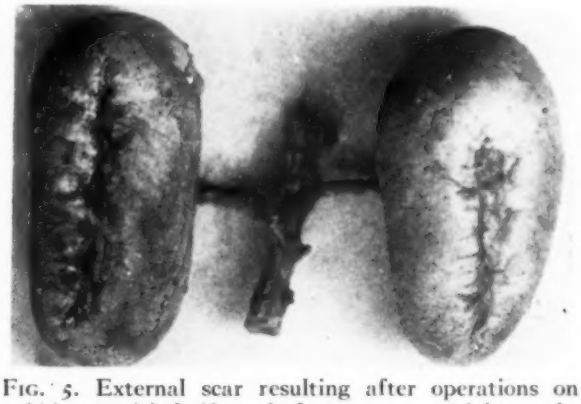

Fig. 5. External scar resulting after operations on kidneys with knife and electrosurgery (eight weeks postoperative).

Operations on the Liver and Spleen. In order to test the efficiency of the electrosurgical "knife" in controlling hemorrhage from incisions in the liver a portion of its lobes were resected. The liver was exposed, traction made upon a lobe and a portion excised (Fig. 2). The procedure was repeated on one or two lobes and the liver replaced in the abdomen. No packing or suture was necessary. Occasionally slight bleeding from the central artery occurred which was quickly controlled by coagulation after clamping, according to the method of Ward.[3]

In a similar manner the end of the spleen was excised. The incision with the current

was begun just external to the vessels of the hilum and carried through the organ resecting the lower pole. The same portion

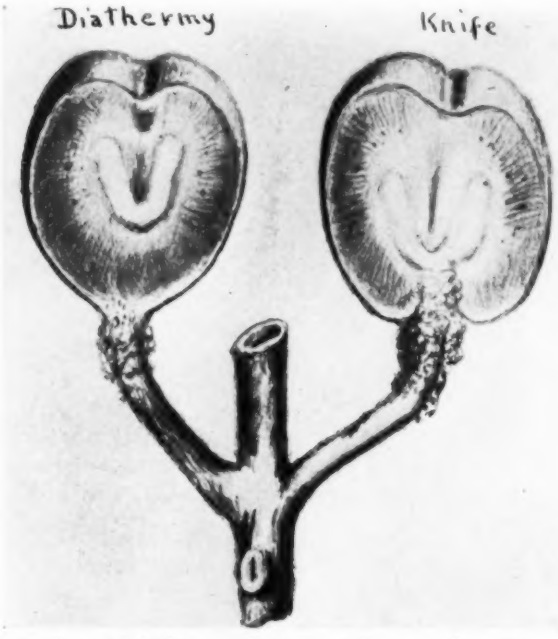

Fig. 6. Scar in kidney substance (three weeks after operation).

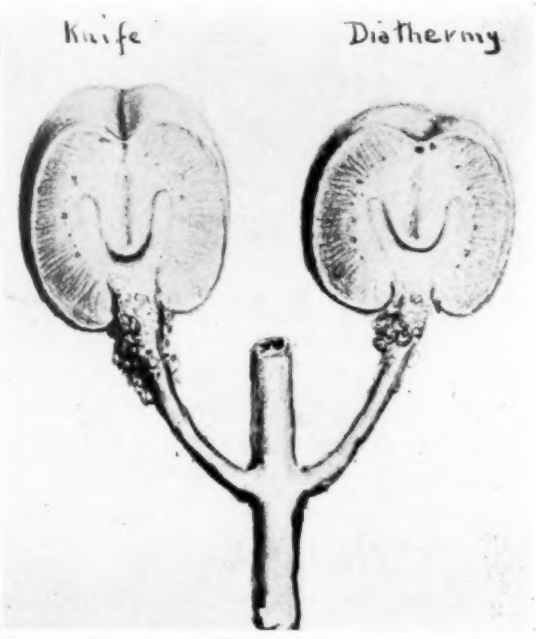

Fig. 7. End-result. Scars seven weeks postoperative showing complete repair.

of the spleen was removed with a tonsil snare through which the current was passed. (Fig. 3.)

In the experiments on the liver and spleen a comparison between the results with electrosurgery and with the scalpel could not be made because of hemorrhage following the operations if performed with a knife.

Current. For the incision through the skin, muscle and fascia the damped current should be smooth (very small spark-gap, consequently low voltage) and have a high amperage and high frequency. The current was considerably modified during the course of the investigation, the primary requisite being to control hemorrhage while cutting without too destructive coagulation. A current was developed which had the properties of coagulation and cutting, being of very high amperage (small spark-gap) and high frequency much of stronger amperage than used in the abdominal incision. It must be borne in mind that an electrosurgical apparatus capable of cutting and coagulating has a greater range of current than a cautery has variation in temperature. Consequently, if a cutting current, such as is used for ordinary dissection, is used upon parenchymatous organs, about as much bleeding is encountered as if a scalpel were employed. This matter of control of current is so important and the variation in different machines so great that further investigation must be done to develop an apparatus which will deliver more uniformly this combined cutting and coagulating current.

RESULTS

The control of hemorrhage at the time of the operation is the important feature of electrosurgery. It was found that this is equally true of operations on the liver, kidney and spleen. In the experiments on the kidney no clamp was placed on the pedicle yet the removal of an elliptical segment from the cortex to the pelvis caused only moderate bleeding. The bleeding usually came from the larger arteries deep in the kidney substance, and these occasionally required clamping and coagulation. Thus it was that dissection and

suture could be carried out with deliberation in a dry field and a more accurate incision and apposition of the cut edges

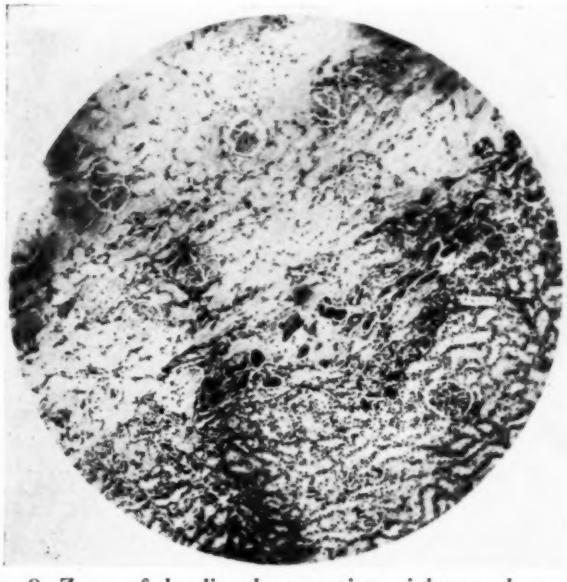

Fig. 8. Zone of hyalin degeneration eighteen days after coagulation.

obtained. The blood lost during this procedure soiled an average of four sponges. This was in marked contrast to the same operation done with the scalpel where the bleeding was profuse and an average of fourteen sponges used. Here speed was necessary to remove the segment and suture the edges before the animal became exsanguinated. Of course, in most operations it is possible to clamp the pedicle but even if this cannot be done electrosurgery will partially control the bleeding.

The repair of the kidney after electrosurgical incision is not dissimilar from that after the scalpel. The scar is broader because of the zone of coagulation at the cut edges. This may be seen in Figure 4 which illustrates the condition twenty-four hours after operation and in Figure 5 showing the appearance eight weeks later. Observation of a cross section of both kidneys from the same animal shows that just as the surface scar is broader so the scar deep in the tissue is more prominent. This is well shown by Figure 6. However, after contraction of the scar the difference is less marked and the result after seven weeks, shown in Figure 7, illustrates how successful is the reparative process after using a high frequency surgical current.

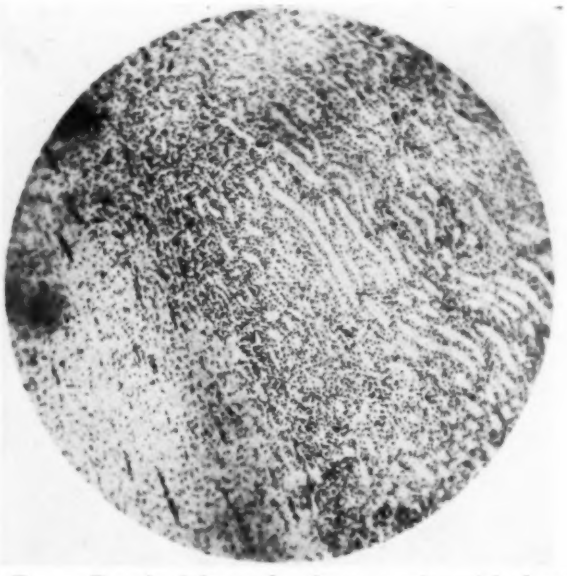

Fig. 9. Repair eight weeks after operation with electrosurgery. Hyalinized material has been replaced by fibrosis.

Microscopic examination of these specimens shows a slight area of carbonization at the periphery with a zone of coagulation beneath consisting of degenerated nuclei scattered through a mass of homogeneous hyalin material, during the process of repair, the coagulated tissue having become uniformly hyalinized. In the zone next the normal tissue are to be found round cells and fibroblasts. This stage is shown by Figure 8. Later the hyalinized material is reabsorbed and replaced, by fibroblastic proliferation and infiltration giving rise to a firm cicatrix, as shown in Figure 9.

In contrast to this sequence of events, healing after scalpel incision occurs with less hyalinization and less round cell infiltration. There being no zone of coagulation, the clot and fibrin are reabsorbed and replaced by connective tissue. The lower tip of such a scar is shown by Figure 10 where it is evident that the reparative reaction is less extensive than in the preceding specimens.

In the removal of a large disc-shaped area from the cortex of the kidney without

subsequent suture little bleeding was encountered. It is probably that, since the incision did not go as deep as that

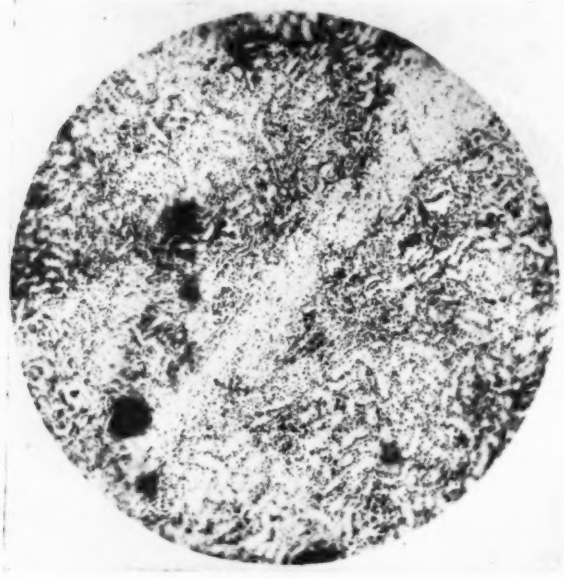

Fig. 10. Scar eighteen days after operation with scalpel. Only lower tip of scar is shown.

previously described the larger arteries were not cut and hence the hemorrhage

Fig. 11. Healing sixteen days after removal of large segment of cortex with electrosurgery without suture. Note size of scar and small unhealed central area.

more readily controlled. In spite of the fact that there was no attempt to repair the defect in the kidney by suture, the healing is satisfactory. In Figure 11, the outline of the smooth scar may be seen with a small unhealed area in its center.

When the entire pole was resected with a tonsil snare carrying the current no bleeding occurred. By this method, greater

Fig. 12. Three weeks after resection of one-half of kidney with electrosurgical tonsil snare.

coagulation was obtained which, though it seared to prevent hemorrhage, was not desirable on account of the excessive destruction of the tissue. The end result shows (Fig. 12) preservation of less healthy, functioning tissue than if the pole had been resected by a strong cutting current in place of the snare.

The removal of a portion of one or more

Fig. 13. Repair of the spleen two weeks after resection of one pole with electrosurgery.

lobes of the liver with the cutting current is one of the most spectacular procedures in surgery. The former methods of controlling hemorrhage from the liver by suture with special needles, by the actual cautery, or by packing with gauze, omentum or muscle are often ineffective and the surgeon is helpless to stop the persistant bleeding. On the other hand with electro-surgery large portions of the liver may be removed, without bleeding. Occasionally there is

slight bleeding from the central artery but this is quickly controlled and at no time was more than one sponge soiled with blood.

Fig. 14. Healing of liver three weeks after removal of portion of two lobes with electrosurgery. No suture of cut edges.

The spleen, on the other hand, is a much less favorable organ to attack with the current. Here the large number and size of the arteries cause the difficulty. These arteries are cut through without being coagulated and arterial hemorrhage is prominent. Because of the softness of the splenic pulp the vessels are difficult to grasp with a clamp, heavy coagulation being necessary to control the bleeding. Almost complete hemostasis is obtained, by resecting a pole with a tonsil snare through which the current is passed but here, as in the kidney, excessive coagulation and destruction of tissue occurs.

In the spleen and liver there is a similar type of repair to that occurring in the kidney. An extensive coagulated area was left exposed which was protected only by covering with omentum. Consequently, repair by fibrosis must result. That this occurs satisfactorily is shown by Figures 13 and 14, where a firm cicatrix is seen covering the defect in these organs. Histological examination of these specimens bears out the similarity of the process of repair to that in the kidney. Figure 15 illustrates the zone of carbonization separated from the healthy tissue by a zone of coagulated, hyalinized debris.

There remains to be mentioned the healing of the incision through skin, muscle and fascia. In every case repair was by primary union and in no instance was a better result obtained by the use of the scalpel. In those instances, where half the incision was made with each instrument, it could not be determined where one left off and the other began. Of course, the current for the abdominal incision was much weaker than that used in the parenchyamatous organs giving a slight zone of coagulation (0.1 to 0.2 mm.).

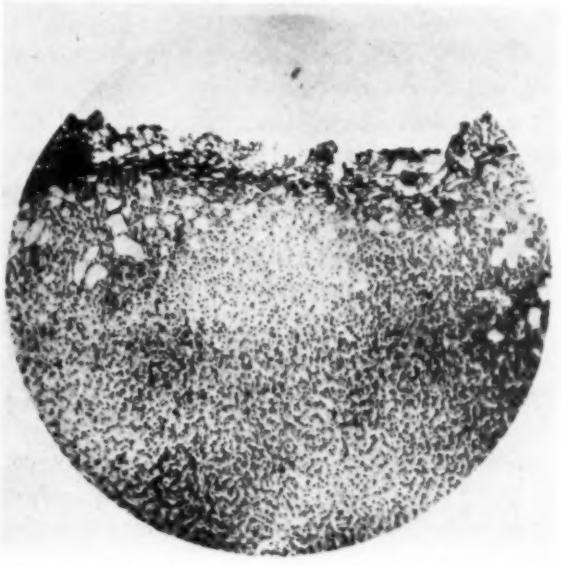

Fig. 15. Effect of current on liver tissue. Zone of carbonization and of coagulation are illustrated.

It is to be expected from previous knowledge of the subject that with the electrosurgical cutting current primary bleeding will be less than with the scalpel. Past experience has also shown that secondary hemorrhage is a frequent complication of electrosurgical operations in the mouth and other infected areas if preliminary ligations of large vessels has not been done. In twenty animals, each of which had two or more organs operated upon, no instance of secondary hemorrhage resulted. Hence, it is seen that if asepsis is observed secondary hemorrhage is abolished.

DISCUSSION

The application of these experiments

to clinical surgery is self evident. The trend of modern methods is to conserve healthy tissue wherever possible. In consequence, nephrotomy, heminephrectomy, nephrolithotomy and plastic operations for hydronephrosis and pyonephrosis are replacing nephrectomy in many cases. These operations necessitate cutting into the kidney substance and are usually bloody, despite all precautions. If the same operation may be accomplished by electrosurgery with less hemorrhage and consequent greater deliberation and accuracy of procedure, then the technic is desirable. Further, it has been shown that large areas of the cortex or even half the kidney may be removed without serious hemorrhage and that good repair results without suture of the edges. Other methods demand suture for hemostasis and if it can not be done nephrectomy is necessary.

The presence, in the liver, of localized pyogenic or amebic abscesses, echinococcus cysts, primary or metastatic tumor nodules give indications for surgical interference. Elaborate methods have been devised to secure hemostasis in the liver. Packing with gauze, rubber tissue, omentum or muscle, the use of the thermocautery, special needles and methods of suture, elastic ligatures, plates of magnesium, cartilage and decalcified bone have all been tried and found unsatisfactory in some particulars. Following the electrosurgical resection of a part of the liver lobe the liver was purposely replaced without suture. Less scarring would result if the cut edges had been approximated but it was desired to show that electrosurgery alone was an effective hemostatic agent.

A word of warning about the current used is necessary. There are many different types of electrosurgical current generators and the general term, electrosurgery, is chosen in this paper to cover a number of different high frequency currents: light cutting for the abdominal incision, heavy cutting for the parenchymatous organs and coagulation for large blood vessels. Consequently, if the surgeon is contemplating the use of electrosurgery on parenchymatous organs, he should first familiarize himself with his own particular machine and determine if it is capable of developing the desired current. In this regard, it is desirable that further investigations be made: (1) to produce a more rapidly coagulating current where larger arteries are to be encountered; (2) to secure a metal or an active electrode which will not adhere to the coagulated tissue. These experiments have demonstrated that electrosurgery offers a hemostatic cutting agent for use in the parenchymatous organs in dogs. The absence of secondary hemorrhage and the satisfactory repair following its use warrant its consideration as a part of the operative technique of vascular structures.

CONCLUSIONS

1. Extensive electrosurgical procedures may be performed on vascular organs in dogs such as the liver and kidney with only slight primary bleeding.

2. In the absence of infection, secondary hemorrhage did not occur.

3. Healing was uneventful and though the scarring was unusually more extensive, than the use of the scalpel, the end result was satisfactory.

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CARCINOMA OF THE ANUS AND RECTUM*

R. A. CUTTING, M.D., PH.D.

NEW ORLEANS, LA.

ETIOLOGY

THE *causa causans* of rectal carcinoma is, of course, unknown. Chronic irritation is presumably a factor in the etiology, and obviously the rectum and anus are peculiarly subject to traumatic and chemical irritation.

PREDISPOSING CAUSES

Amongst predisposing causes tissue predisposition is frequently mentioned. It is asserted that carcinoma develops on the basis of (1) simple benign tumors of the rectum, especially adenomata, and (2) chronic inflammatory conditions of the rectum and anus, such as hemorrhoids, fistulae and anal tags.

Thus, of 37 cases admitted to Baylor hospital, 14 revealed hemorrhoids, 3 previously benign polpi, 2 fistulae, and 1 malignant degeneration in an anal tag.[1]

Many proctologists, notably Lockhart-Mummery, believe the commonest origin is in the simple adenomas which develop from the glands of Lieberkühn.

However, Ewing quotes Kraske with approval as expressing the belief that "There is no satisfactory evidence that cancer develops in tissues altered by hemorrhoids, fistulae, or cicatrices," and expresses himself as being satisfied that the only definite instance of tissue predisposition as a factor in the development of rectal carcinoma occurs in connection with multiple polyposis.

RELATIVE FREQUENCY OF RECTAL CARCINOMA

Next to the stomach, the rectum is the most frequent site in the gastro-intestinal tract for the development of carcinoma. Hirschman and Rosenblatt state that 50 per cent of all cancers occur in the intestinal tract and that 16 per cent are cancers of the rectum or sigmoid colon. Of 123 intestinal carcinomas Kaufman (quoted by Ewing) found 51 in the rectum; he is authority for the statement that over 60 per cent of intestinal carcinomas and 5.25 per cent of all carcinomas occur in the rectum; this puts the rectum fifth in the order of frequency of all the sites of primary carcinoma in the body. At the Pathologic Institute of Vienna, 47.2 per cent of all intestinal carcinomata examined between 1870 and 1893 occurred in the rectum (quoted by Ewing). Russell (quoted by Fitchet), basing an estimate on the work of Gant, Ball, and Halstead, estimates that 80 per cent of intestinal cancers involve the rectum. Jones states that 12 per cent of all carcinomata occur in the intestinal tract and that of these 55 per cent occur in the rectum.

AGE INCIDENCE

The disease is characteristically one of patients past middle life. Murdock states that two-thirds of the cases occur in individuals between forty and sixty years of age. However, the disease is by no means confined to those of advanced years. Steiner[2] reported a case in a boy of nine years. The Allinghams[3] reported a case in a boy thirteen years of age. Phillips[4] collected from the literature all the cases up to 1908. Warthin[5] reported 2 cases in persons under thirty years of age as the result of the study of 2000 specimens. Pennington[6] collected 40 cases of patients under twenty years of age from 7174 reported cases. Fowler[7] quoting statistics from the Mayo Clinic, reported 14 cases in ten years. Clark[8] was able to collect 51 cases from the literature to date, and added one of his own. Loewenberg[9] added 1 case, that of an eighteen year old boy. Spittler[10] reported a case of a patient

* From the Department of Surgery, School of Medicine, Tulane University of Louisiana, New Orleans, La.
Submitted for publication July 21, 1930.

eighteen years of age. Da Costa[11] reported a case in a white male nineteen years of age.

SEX INCIDENCE

Males are affected more frequently than females. The ratio between the sexes in some series of cases is as high as two to one.

PATHOLOGY

MICROSCOPICAL ANATOMY

Carcinomata of the rectum, except for the occasional squamous-cell epithelioma or epidermoid cancer, which occurs at the mucocutaneous junction of the anus and arises from skin epithelium, are adenomatous or glandular in type. Microscopically they range in structure all the way from virtually normal rectal gland formation to an architecture in which almost all traces of gland formation are lost.

Ewing classifies rectal carcinomata in the order of frequency of their occurrence as: (1) adenoma destruens, (2) stenosing fibrocarcinoma, (3) gelatinous adenocarcinoma, (4) bulky polypoid or papillary carcinoma, (5) multiple carcinoma following polyposis (6) acanthoma, and (7) melanoma.

GROSS PATHOLOGY

Fitchet states that between 50 and 60 per cent of all rectal carcinomata occur in the region of the midrectum, and Wheeler states that 90 per cent of growths situated in the rectum, rectosigmoid, or lower sigmoid can be palpated by simple rectal or bimanual examination.

According to their gross appearance carcinomata may be classified as (1) papillary, (2) polypoid, (3) mucoid, (4) ulcerating, (5) infiltrating, and (6) "napkin-ring."

Carcinomas of the rectum always tend to infiltrate the wall of the intestine in a circular manner, and relatively rarely to encroach upon the lumen except by concentric stenosis. Clemons states that only 1 out of every 30 lethal carcinomas projects perceptibly into the lumen of the rectum.

SYMPTOMS AND SIGNS

The earlier symptoms and signs are often vague, and never pathognomonic. They depend upon (a) ulceration, (b) stenosis, and (c) tumor formation. They consist of: (1) changes in previous bowel habits, especially constipation, and, when present, "morning diarrhea"; (2) a sense of discomfort in the rectum not relieved by defecation; (3) pain, usually noted rather early in anal carcinoma, infrequently and late in the ampullary and rectosigmoid types; (4) bleeding, which may be inconsiderable in amount and consequently overlooked, but "all rectal cancers bleed" (Rosser).

In the intermediate stages the symptoms and signs are similar but more pronounced:

(1) Constipation or alternating constipation and diarrhea.

(2) Increasing local discomfort.

(3) Moderate pain depending especially, as just previously noted, upon the type of carcinoma.

(4) The discharge of blood, either alone or in combination with mucus or pus, and

(5) Moderate loss of weight.

Rankin, reporting the Mayo Clinic statistics, in an unclassified grouping of cases, for the ten year period ending January 1, 1916, which were based on 602 cases of rectal carcinoma, gives the percentage of incidence of the cardinal symptoms as:

(1) Rectal bleeding 89.5 per cent of cases.

(2) Constipation 55 per cent.

(3) Diarrhea 20 per cent.

The classical textbook symptomatology of rectal carcinoma as given in the older literature, which includes anemia, cachexia, "ribbon-stools," and the symptom-complex characteristic of low intestinal obstruction, represents a terminal stage of the disease, which should never be allowed to develop in the presence of moderate methods of diagnosis and treatment.

DIAGNOSIS

It should be a cardinal principle in diagnosis to suspect the presence of a

rectal carcinoma in all patients past forty years of age in whom the regular routine of bowel action becomes upset. The presence of a malignant tumor of the lower bowel is also to be suspected in any adult in whom there is rectal bleeding which cannot be accounted for by parasites or bacteria.

Rectal carcinomata are usually correctly diagnosed if patients are intelligently and thoroughly examined. However, in many series of cases more than half of the rectal cancers are inoperable when first diagnosed, and the fact that 26 per cent of all cases diagnosed at the Mayo Clinic had previously been operated upon elsewhere for hemorrhoids without adequate preliminary rectal examination, demonstrates that most rectal examinations are woefully superficial.

Although not necessarily directly evidencing improper previous medical attention, it is nevertheless significant that the duration of symptoms at the time of diagnosis in most cases has been far too great. In a series of 41 cases reported by Turner the average duration of symptoms was nine months, and Rankin and Broders state that the duration of symptoms of patients seen at the Mayo Clinic averages more than twelve months.

Malignant growths are apt to be solid or hard; they tend to penetrate between the mucosa and the muscular coats of the bowel for some distance, and do not tend to project into its lumen, as previously stated; however, growths which do project into the lumen and which present a broad infiltrating base are to be considered malignant.

Two fairly characteristic types of rectal carcinoma may be described particularly:

(1) A single elevated ulcer with necrotic crater and normal periphery, and

(2) A firm granular bleeding mass growing somewhat into the lumen of the bowel and having an indurated base.

In addition to these two varieties representative of the medullary type of growth there is, of course, the scirrhus variety which tends to produce an annular stricture.

In cases of doubt biopsy material may be taken deliberately and without hesitancy from projecting lesions, because they tend to be benign, but in the more suspicious cases and those in which the tumor mass is infiltrating in type, it is a safer procedure to be prepared to undertake operative treatment directly following the biopsy in case a "rush" frozen section indicates malignancy in the tissue removed.

MODES OF EXTENSION

Although fixation and marginal infiltration are characteristic of carcinomata of the rectum ordinarily, in its earliest clinical stages carcinoma of the rectum is confined to the rectal mucous membrane and the immediately adjacent submucous tissue. The growth is sessile and freely movable.

The extensions of the primary growth in accordance with which local fixation and distant metastasis occur have been described in classical form by Miles.[12]

Extension occurs by three different channels:

(1) By direct extension through continuity of tissue.

(2) Through the venous system.

(3) By way of the lymphatic system.

1. Primarily growth by direct extension occurs circumferentially in the mucous and submucous layers. The amount of circular infiltration, at least in cases involving the ampulla of the rectum, is roughly commensurate with the duration of the disease. Growths involving more than three-fourths of the entire circumference of the bowel have probably existed for more than one year.

Infiltration radially into the muscular tunics of the bowel wall occurs secondarily and fixation of the growth to the submucosa tends to begin at the oldest part of the neoplasm. Moderate fixation is characteristically established by the time one-half of the circumference of the rectum has become involved. In more advanced stages the neoplasm permeates structures

beyond the actual wall of the intestine, though permeation of extrarectal tissues is held in abeyance for a considerable period of time by a lymph sinus, which surrounds the rectum and separates it from the perirectal fat.

Penetration of the fascia propria occurs usually only after the growth has involved three-fourths or more of the circumference of the bowel which, as previously noted, indicates that the malignant process has been active for a year or more.

Fixation of the growth to the sacrum, prostate, bladder, uterus or vagina indicates extension of the neoplasm beyond the rectum except in certain cases in which the reaction is purely inflammatory and the fixation is due to excess fibrous connective tissue formation.

2. Venous extension constitutes a relatively rare mode of metastasis, but that it does occur is evidenced by the occasional accidental finding of carcinomatous nodules in the liver on opening an abdomen for carcinoma of the rectum obviously not very far advanced.

3. Lymphatic extension, by far the most important mode of metastasis, is by way of the lymph stream.

The lymphatics, draining the rectum, consist of an intramural group and extramural group.

The intramural group is a relatively unimportant one from the point of view of carcinomatous metastasis. There are in the rectum lymph vessels both in the submucous connective tissues and in the space between the circular and longitudinal muscle coats, both of which communicate by short radial vessels with one another and with the perirectal lymph sinus previously mentioned.

The extramural group is of far greater importance.

The extramural lymph-drainage system begins in a series of lymph glands which develop at different levels, along the rectum, which stud the surface of the rectum, and which are called anorectal glands. From these glands there are three efferent lymph-routes: (1) the downward; (2) the lateral, and (3) the upward.

The downward route terminates in the internal iliac group of glands, having traversed the ischiorectal fossa and Alcock's canal; the tissues along this route include perianal skin, the ischiorectal fat, and the external sphincter muscle.

The lateral route terminates also in the internal iliac glands but traverses the area between the levator ani muscles and the rectovesical fascia, and includes in its course a gland near the obturator vessels; the tissues constituting the zone of lateral spread include especially (1) a group of lymph glands in the retrorectal space and (2) the levator ani muscles, but also the base of the bladder, the seminal vesicles in the male, and in the female the posterior wall of the vagina, the cervix uteri, and the base of the broad ligament, including Poirier's gland.

The upward route terminates mainly in a group of glands at the bifurcation of the left common iliac artery, having accompanied in its course the superior hemorrhoidal vessels behind the rectum, and also having traversed the retrorectal lymph glands and the subperitoneal area at the line of attachment of the pelvic mesocolon. From the uppermost anorectal glands lymph vessels also pass to the paracolic glands. The tissues included in this zone of spread are most important: the pelvic peritoneum, the entire pelvic mesocolon, and the paracolic lymph glands.

Although carcinoma of the lower part of the rectum tends to metastasize by the downward route, carcinoma of the upper part of the rectum to metastasize by the upper route, and intermediate carcinoma by the lateral route, all three routes intercommunicate, and carcinoma abides by no fixed rule in its metastasis.

TREATMENT

The treatment of cases of carcinoma is essentially surgical. The only known method of completely eradicating carcinomatous growths in the anus and rectum, as

elsewhere, is radical surgical extirpation, either with the knife, the actual cautery, or the high frequency current of electricity.

PALLIATIVE TREATMENT

As previously stated, due to the fact that the diagnosis of rectal diseases is backward, many cases of rectal malignancy are not diagnosed and referred to the surgeon at a sufficiently early time to permit satisfactory operative treatment; in such cases *x*-ray and radium therapy may be of considerable value in rendering the latter days of the patient comfortable; but with the exception of a few ultra-optimistic radiologists, the accepted opinion is that deep *x*-ray therapy and radium applications are valueless as curative agents. Lockhart-Mummery[13] says that *x*-ray and radium have probably never cured a case of carcinoma of the rectum.

The performance of colostomy is of the greatest value as a palliative measure in relieving obstruction, diverting the stream of irritating and traumatizing bowel contents from the region of the growth, and minimizing infection of ulcerated areas. Through the colostomy opening the lower bowel may be irrigated, and thus ulcerating areas may be actively cleansed of debris. Furthermore, the application of radium from above through the colostomy wound is made possible in certain cases.

The advocated methods for *x*-ray and radium therapy consist (1) in the insertion of heavily filtered gold seeds; (2) in irradiation by the element pack and (3) in the administration of high voltage roentgen rays. These methods should not, of course, be neglected postoperatively in cases of radical excision of growths in which their use is indicated, because of the suspected incompleteness of removal of neoplasms.

Lockhart-Mummery is virtually alone in recognizing the value of colloidal copper; he states that he knows of 2 cures in 200 cases treated by this agent. This author also thinks that colloidal lead holds some promise, but recognizes that it is a dangerous therapeutic agent.

OPERABILITY OF CASES OF CARCINOMATA OF RECTUM

The average duration of life in untreated cases with carcinoma of the rectum is twenty-one months. Lockhart-Mummery knows of one patient who lived seven years, but on the other hand, many patients die early. It is universally agreed that the most suitable cases for operation are those which present only a small local growth, and in which neither fixation of the rectum nor involvement of the regional lymph glands has occurred. In such cases Lockhart-Mummery reports 73.7 per cent of "five year cures."

However, it is not always easy to determine in any actual clinical case whether these conditions do or do not prevail until the abdomen has been opened, and in any event, in estimating the operability of a case the age of the patient cannot be overlooked, since in patients under thirty years of age the growth recurs promptly and with virulence in all cases. Lockhart-Mummery has never heard of a cure in rectal carcinoma in patients under thirty years of age. Tuttle states that no case of radical cure has ever been reported in patients under twenty-five years of age.

For obvious reasons metastases to distant parts, e.g. the peritoneum and the liver, contraindicate any but palliative operations.

Diffuse lymphatic involvement in the areas adjacent to the neoplasm does not necessarily indicate inoperability, since in many cases the glandular involvement is found not to be carcinomatous, but inflammatory at biopsy. Furthermore, satisfactory removal of the involved area is frequently possible.

Fixation of the growth may or may not indicate inoperability, depending upon the position, density and bulk of the limiting fibrous tissue. In certain cases it is possible to remove part of the prostate and the seminal vesicles in toto, and usually fixation to the hollow of the sacrum is not an insurmountable operative difficulty.

In deciding for or against operability

it is important to know that, except in young patients and in a few older patients who show early metastasis to the liver, metastases in rectal carcinomata occur unusually late in comparison with carcinomata elsewhere in the body. In contrast to gastric neoplasia, the size of rectal carcinomata bears no relation to the malignancy of the growth. Sixty-eight per cent of the cases in one series reported by Jones and McKittricks[14] showed no involvement of the perirectal tissues or lymph glands at autopsy. Miles finds metastases in his cases as follows:

(1) To the inguinal glands, in 27 per cent of cases.

(2) To the liver in 10 per cent of cases.

(3) To the pelvic organs in 9 per cent of cases.

(4) To the retroperitoneal glands in 6 per cent of cases.

(5) To the lungs in 4 per cent of cases.

(6) To the perineum in 3 per cent of cases.

(7) To the femur in 2 per cent of cases.

Rankin and followers of the Mayo Clinic attach considerable importance to the determination of degree of malignancy according to the method of Broders. Rankin and Broders have found that their surgical results in grade 1 malignancies with metastases are almost as good as in grade 3 and 4 malignancies *without* metastases.

Rectal carcinomas showing marked tendency toward mucus production are relatively benign, and the greater the tendency toward mucus production, the more benign is the lesion. Ochsenhirt[15] graded 188 cases of carcinoma of the rectum for mucus content from 1 to 4, grade 1 representing a growth in which less than 25 per cent of all the cells were involved in mucus production, grade 2 in which more than 25 per cent and less than 50 per cent were so involved, grade 3 in which more than 50 per cent but less than 75 per cent, and grade 4 in which more than 75 per cent were mucus secreting cells. He then compared his grading for mucus production with that of Broders for malignancy, and found an inverse ratio.

Summarizing the matter of operability, it may be said that some surgeons will choose to operate upon a larger number of cases than others, and the mortality rate and percentage of recurrences of such surgeons will tend to be high; others, more conservative, will refuse a larger number of operations with a corresponding decrease in mortality and morbidity.

In Rankin's series 54.7 per cent of cases were deemed suitable for either radical or palliative operative procedures, and this figure represents very well the situation with respect to the class of competent surgeons who are neither unduly radical nor unduly conservative.

Miles[12] in 1923 reported 589 cases of carcinoma of the rectum with a percentage operability of 29.3 per cent.

In Jones series, reported in 1928, the percentage operability was 65 per cent.

RADICAL TREATMENT

Because of the fact that carcinomas tend to invade the tissues of the host widely and because the limits of extension cannot be definitely outlined by any known means the mere local excision of malignant neoplasia anywhere in the body has rightly become an obsolete procedure except in a very few cases in which secondary infection or the mere size or position of a growth makes such a procedure desirable as a palliative procedure. Carcinoma of the rectum is no exception to the rule, and local excision of carcinomas of the rectum, except in a "very few exceptional cases, is no longer practised" (Lockhart-Mummery).[16]

Because of the position and physical relationships of rectal carcinomata the demonstrable limits of the growth are very difficult to determine. The rectum, lying as it does, in the depths of the bony pelvis is peculiarly inaccessible to ordinary non-surgical manipulative procedures, and a considerable part of the metastatic drainage area being deep in the abdomen,

evidences of metastasis to this area are also difficult to demonstrate or actually impossible of demonstration while the abdomen is closed. Since almost all of the advance in the surgical treatment of carcinoma has come about as the result of an understanding of the process of metastasis and the application of the principle of the wide excision of tissue for the purpose of removing all possible extensions of the malignant process, any operative attack which proceeds in the absence of a thorough examination for possible metastatic foci would seem to be irrational. For this reason the methods of operating upon carcinomata of the rectum which do not include a thorough exploration of the abdominal cavity and the concavity of the pelvis through an adequate abdominal incision are rapidly falling into disrepute.

If this operative principle is to be respected many of the older operations for carcinoma of the rectum must be considered obsolete. The most satisfactory of the operations of the type which proceeded in the absence of intra-abdominal and pelvic manipulations was the procedure most frequently known by the name of Kraske. Kraske did not introduce the method of perineal approach into surgery; the credit for this belongs to Lisfranc who practiced simple incision through the soft tissues of the perineum. The original operation was modified by Kocker in 1875 to include resection of the coccyx and by Kraske in 1885 to include resection of part of the sacrum for purposes of obtaining better exposure.

The classical Kraske operation as practiced for many years consisted in a preliminary colostomy, followed in a few days by removal of the coccyx together with the last segment or two of the sacrum and the radical removal of the growth through the portal thus formed. Many slight modifications enjoyed varying degrees of favor, specifically the modifications of Bardenheuer, Hochenegg, Rydygier, Rehn, Tuttle, and Murphy.

From the point of view of operative mortality the Kraske type of operation was not unsatisfactory. The mortality at the Mayo Clinic was about 25 per cent, and many surgeons, by subordinating the factor of completeness, were able to reduce the percentage of primary mortality to 15 or even 12, but the percentage of recurrences, regardless of the primary mortality, was invariably very high. As an example of the results obtained by excellent surgeons may be mentioned the statistics of Miles.

Between the years 1889 and 1906 Miles performed 55 operations for resection of the rectum by the perineal route, varying his technic slightly during this period of time. The operative mortality for every year but one was nil (1904–1905, 7.6 per cent) but the percentage of recurrences varied between 91.6 and 100 per cent.

In the early years of the present century, Miles was engaged in the development of a technic which would be capable of removing all of the tissues particularly susceptible to metastases.

According to Miles metastases may occur in the ischiorectal fat, the levator ani muscles, the retrorectal lymph glands and the pelvic mesocolon, and any operation for carcinoma of the rectum which does not remove these tissues, whether grossly invaded by carcinomatus nodules or not, is of relatively little value, since, at least theoretically, the removal of every microscopical evidence of the neoplasm must be accomplished in order to avoid recurrence.

This wide dissection is undertaken by Miles in one operation by a combined abdominoperineal approach.

Since 1906 Miles, (operation described originally in *Lancet* for Dec. 19, 1908 by Ernest Miles) has routinely performed the radical abdominoperineal operation, excising the pelvic colon entire (except the part utilized for forming a colostomy opening) the rectum entire, the pelvic mesocolon entire, the peritoneum lining the floor of the pelvis, together with a strip on either side of the parietal attachment of the pelvic mesocolon, the levator ani

muscles entire, the external sphincter muscle, as much as possible of the ischiorectal fat, and a wide area of perianal skin.

From 1906 to 1920 he had performed 72 such operations with operative mortalities of 40, 26.3 and 18.1 per cent in three series consisting of 42, 19, and 11 cases, respectively, with a percentage of recurrence in the 55 cases which he was able to follow, of 28.5 per cent. Of the latter 55 cases the number of those known to have been alive and well in 1920 and the postoperative period covered were respectively as follows:

1—after eleven years
4—after nine years
3—after eight years
3—after seven years
4—after six years

Jones,[17] who is the most ardent advocate of the single stage resection of the rectum in this country, offers a technic which in outline is as follows:

PRELIMINARY PREPARATION

(1) The colon is cleansed by the administration of magnesium sulphate by mouth and the administration of enemas for several days.

(2) The blood-pressure is raised in cases in which an elevation is desired by the administration of ephedrine in doses of ¾ grain T.I.D.

ABDOMINAL OPERATION

(3) Spinal anesthesia is induced, introducing the spinal needle between the first and second dorsal vertebrae.

(4) In the Trendelenburg position a long midline, or left rectus, incision is made.

(5) The liver is palpated for evidences of metastases and the pelvis is explored for enlarged glands.

(6) If the case is considered favorable for radical resection of the neoplasm, the intestines, except the sigmoid flexure of the colon, are packed off with gauze into the upper abdomen and the inferior mesenteric artery is ligated at a point about 1 in. below the bifurcation of the aorta, care being taken not to injure the left ureter.

(7) The peritoneum is incised on either side of the mesosigmoid down to the promontory of the sacrum.

(8) Using the finger, the pelvic mesocolon is separated by blunt dissection from the anterior surface of the sacrum as far down as the sacrococcygeal articulation.

(9) Traction is exerted on the bowel, and the peritoneum of the pelvic floor is incised forward to the base of the bladder in the male or the upper part of the vagina in the female.

(10) The anterior wall of the rectum is separated from the base of the bladder, in the male down to the upper border of the prostate (avoiding injury to the vas deferens and the seminal vesicles) and in the female from the posterior wall of the vagina.

(11) The lateral attachments of the rectum are divided down to the levator ani muscles.

(12) The rectum is divided with the cautery in a place favorable for colostomy, and the divided ends are invaginated by means of a purse-string suture.

(13) The distal end of the divided rectum is pushed down into the pelvis, and the pelvic peritoneal lining is restored, making peritoneal flaps from the base of the bladder in the male or broad ligament, in the female.

(14) Colostomy is performed, and closure of the abdomen is affected.

PERINEAL OPERATION

(15) The patient is turned on the abdomen and, with the hips elevated slightly, a purse-string suture is placed about the anus.

(16) An elliptical incision is carried through the skin from the sacrum to the perineum, skin flaps are dissected backward, and the coccyx is removed.

(17) The coccygeus muscle is divided, the distal end of the bowel is pulled down, and the levator ani muscles are divided at their point of origin from the lateral walls of the pelvis.

(18) The anal canal is dissected free

from the tissues anteriorly, care being taken not to damage the membranous portion of the uretha in the male.

(19) The large space latterly formed is left to fill by a process of granulation, rubber dam being placed in the bottom of the space and packing material being inserted to distend the space.

Jones reports Miles' complete statistics as follows:

In 116 cases the mortality rate was 25 per cent; the mortality prior to 1914, during the period in which generally anesthesia was used, was 36 per cent, but since 1914, using spinal anesthesia and nitrous oxide gas, it has been only 9.4 per cent.

Jones himself in January, 1928 had performed 15 radical one-stage operations for rectal carcinoma, with 1 death (mortality 7 per cent). The longest postoperative period of survival was two and one half years. Only 1 case showed recurrence.

Among American surgeons the one-stage radical operation for carcinoma of the rectum has not been very generally accepted. As early as 1914 Coffey had begun the elaboration of his classical "two-stage operation," and this operation has progressively increased in favor.

According to Coffey, few parts of the body are as favorably situated for the control of blood supply and removal of all necessary tissue as the rectum.

Most of the blood supply of the ampulla of the rectum and rectosigmoid as well as the other tissues in the hollow of the sacrum comes through the superior hemorrhoidal artery. The venous and lymphatic supply follows the artery.

The two-stage operation has the advantages that it does not place (1) the strain of repair of a widely traumatized area above the pelvic peritoneum, and (2) that of defense against infection from the region of the perineum upon the patient both at the same time.

A more radical procedure than his two-stage operation is irrational, according to Coffey, since the ideal to be striven for is not the complete eradication of the malignancy at the expense of a high mortality, but rather the saving for patients as a whole of as many days of comfortable life as possible.

According to Coffey's development of operative technic, the essential part of the radical resection of the rectum was a laparotomy in which

(a) A permanent colostomy was made.

(b) Interruption of the blood supply and lymphatic drainage of the rectum at the promontory of the sacrum was performed by ligation of the superior hemorrhoidal vessels, and contiguous tissue, and the entire area thus devitalized was mobilized and pushed down within easy reach of a perineal incision.

(c) A so-called "quarantine pack" was placed over the devitalized area to prevent contamination of the clean area above by the devitalized area below and also to conduct away debris which would subsequently form.[18]

The next step in the evolution of the classical "Coffey operation" was the placing of a gauze wick drain in the hollow of the sacrum to protrude in the female through the posterior fornix of the vagina and in the male through an artificially fabricated tube of peritoneum to an opening in the skin of the anterior abdominal wall above the bladder and pubis.[19]

In order to adapt the general plan of the operation to carcinomata in the region of the rectosigmoid junction, in which class of cases inversion of the rectum was frequently impossible due to obstruction of the lumen of the gut, such inversion being an essential part of the technic previously developed, another modification was added. This consisted in complete mobilization (1) of the part of the rectum between the level of the promontory of the sacrum and the region below the growth, separating the rectum and perirectal tissues from the sacrum and coccyx behind and from the vagina in front, (2) doubly clamping the gut with long handled clamps and severing the intestine between the clamps, and (3)

removing the upper clamp together with the growth, and bringing the handles of the remaining clamp through the peritoneal encasement along with the quarantine pack.[20]

A similar procedure was adopted subsequently for growths low in the rectum which likewise did not permit the preliminary passage of a rectal tube for purposes of invagination. The growth, in this case was, of course, not removed until the secondary operation.

The second-stage operation follows the first after a period of time sufficient to ensure (1) firm union of the peritoneum above the quarantine pack, (2) complete healing of the abdominal wound and (3) satisfactory functioning of the artificial anus. At this time the patient's pulse and temperature should be virtually normal, and the function of the gastrointestinal tract above the artificial anus should be completely established.

The secondary operation removes the coccyx and lower piece of the sacrum and subsequently, by blunt dissection, the lower end of the rectum, quarantine pack, devitalized tissue and any pus which has accumulated. In the female the vaginal mucous membrane and perineum are split and the posterior wall of the vagina is either removed or left behind depending upon whether the growth impinges upon it or not.

Application of a large dose of radium is subsequently made in the cavity thus formed, either in conjunction with the primary operation or several days later (usually four) in connection with the first or second postoperative dressing of the wound. Postoperative dressings are subsequently applied in such a manner as to enforce granulation from the bottom of the wound.

In 1924 Coffey[20] reported a series of 47 cases of patients operated upon by his method with only 2 deaths. He feels that the prognosis in cancer of the rectum when treated in this manner is better than that of carcinoma of either the stomach or uterus.

That not all authorities are agreed with regard to the opinions expressed by the most ardent advocates of the radical one and two-stage operations should be mentioned.

Rankin[21] reports 602 resections for true carcinoma of the rectum (omitting the rectosigmoid type) at the Mayo Clinic during the ten year period Jan. 1, 1916 to Jan., 1926 with a hospital mortality of 8.9 per cent.

The types of operation used during this period were,

(1) Colostomy and posterior resection
(2) "Jones" or "Miles" procedure
(3) Coffey operation
(4) Quenu-Tuttle or Harrison-Cripps type of perineal excision.

Jones believes the best operation for the average surgeon is colostomy and posterior resection of the rectum, but he thinks this is a compromise, the ideal operation being a one-stage abdominoperineal resection, and the next best operation being the abdominoperineal two-stage operation.

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[For Additional References and Bibliograpy see p. 561.]

TECHNIC OF ROUTINE PRIMARY REPAIR OF LACERATED POST-PARTUM CERVICES IN PRIMIPARA

(A PRELIMINARY REPORT)

WILLIAM H. EMRICH, M.D.

LOUISVILLE, KY.

LABOR has been described as physiological; recently more often as pathological. I wonder if it has not always been the same except that today we are better qualified to interpret correctly each influencing factor. Labor is and has always been destructive. Like a retreating army, it tears down the bridges behind it, entering an area of pathology. Many are the mothers who date their ill-health from a confinement.

Surgery in its early history was in the hands of itinerants; obstetrics was in the hands of midwives. Surgery has made greater strides because most surgery can be done at an appointed hour, when the operator is refreshed after a night's sleep and all essentials have been arranged.

Not so with obstetrical work. Most labors begin and terminate when the sun is beyond the horizon, during the hours intended by nature for rest and sleep. Those among us who have found it necessary to keep an operative engagement the morning after a sleepless night, know the effort required to be equal to the occasion.

A legend might very properly be written upon the revelations of the vaginal speculum. Cervices by the score, torn, lacerated, everted, excoriated; every stage of malignancy the finale of an early chapter. Volumes have been written upon "The Value of an Ideal." Inspiration born of desire leads us then to just one conclusion, namely, that each and every woman may enjoy the same health after her delivery as before her pregnancy.

"Inaction spells ruin." The medical world however is never inactive.

I am sold on the idea of routine primary repair of the post-partum cervix.

Visualize what confronts you at the end of the second stage of labor; slight to moderate bleeding from a torn perineum, a torn cervix and partially separated placenta.

All vaginal tracts will have previously been swabbed or syringed with 4 per cent or stronger mercurochrome solution or other recognized antiseptic.

A yard roll is packed into the vaginal tract; all bleeding points in the torn perineum are tied; perineal sutures are placed but not tied. Yard roll is removed and placenta is delivered. Ergot or obstetric pituitrin or both are given hypodermatically.

Next to controlling the all-obscuring flow of blood, finding proper and practical bladder and perineal retractors proved to be no small task. These retractors, which are in use at the Chicago Lying-In Hospital, were finally found. However, the nurse holding the retractors and trying also to hold other instruments and sutures permitted the retractors to slide out of position. You can imagine the mess things were in during my early endeavors; blood flowing over everything, retractors slipping, while looking for the cervix I could not see.

Finally, I drew a diagram specifically stating the dimensions of all parts. This instrument which I submit for your inspection is the result. It is very practical (Fig. 1).

By use of this mechanical retractor in the post-partum vagina, the markedly edematous tissues and those parts that are thinned out and retracted can be more readily found. A headlight is the most satisfactory illumination.

To understand the points I wish to emphasize it is necessary to understand the mechanical features as I conceive them.

* Submitted for publication May 19, 1930.

Note carefully the shape of the cervix at the end of pregnancy, as observed by Waldeyer, by Braune and Zweifel, and by the author. The anterior lip is larger in every dimension, than is the posterior lip (See Figs. 2 and 3).

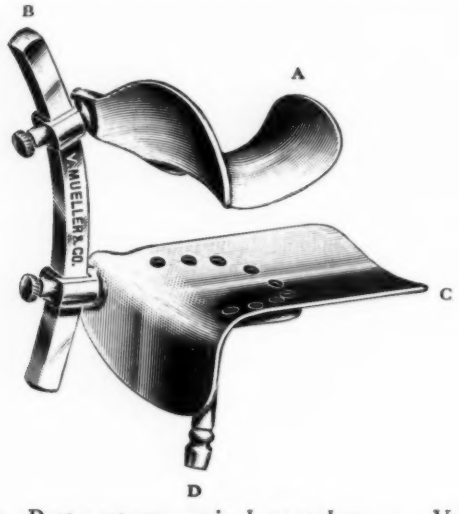

Fig. 1. Post-partum vaginal speculum. A. Vesicle blade hooks under os pubis holding firmly in place. B. Curve of bar spreads distal ends of blades. C. Perineal blade engages snugly in perineal pouch. D. Suction arrangement to keep field dry.

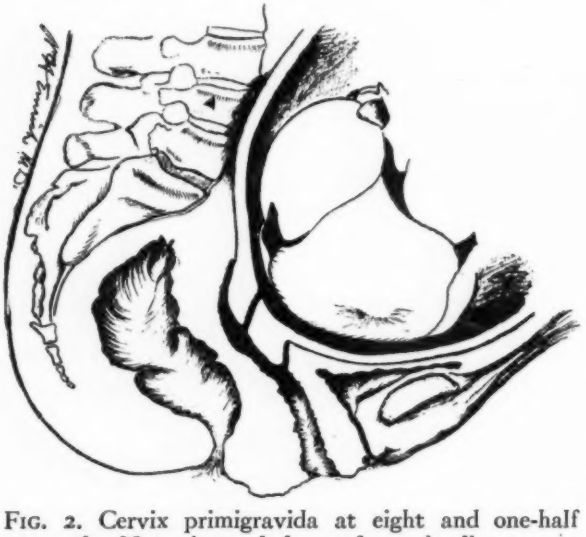

Fig. 2. Cervix primigravida at eight and one-half months. Note size and shape of anterior lip as compared with posterior lip. Pressure of gravid uterus on os pubis and anterior brim of pelvis increases from eight and one-half months until after delivery, causing edema of anterior lip.

When making a vaginal examination of a patient in labor, in the majority of instances you find the os far back in the vaginal tract. Toward the end of the first stage of labor, you most often find a thickened resistant anterior lip grasping the vertex, the posterior lip retracted high up and out of reach. And many is the time that we all make pressure upward on the anterior lip to expedite delivery.

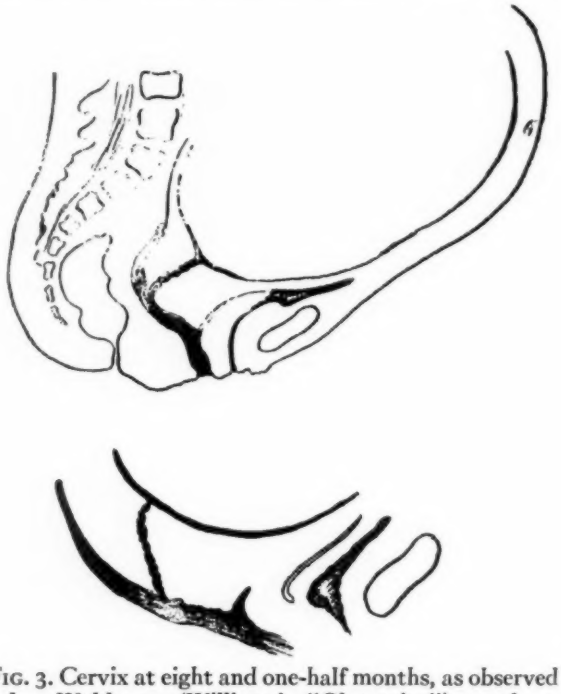

Fig. 3. Cervix at eight and one-half months, as observed by Waldeyer (Williams' "Obstetrics"), and as observed by Braune and Zweifel (Williams' "Obstetrics").

The weight of the pregnant uterus rests heavily upon the anterior surface of the lower segment of the uterus, against the os pubis and the anterior brim of the pelvis (Fig. 2). This induces an edema of the anterior lip because there is no area in the anterior segment to take care of return circulation. During false and true pains this pressure with resulting edema is intensified.

The left occipito-anterior position is present in 70 per cent of vertex presentations. This is due to a full sigmoid pushing the pregnant uterus to the right. In labor this same empty sigmoid acts as a buffer, thereby permitting a return circulation from the posterior cervical segment and preventing edema in the posterior lip. The sacral promontory is the only point

pressing hard against the uterus in back. Even the right iliac fossa in which the brow is engaged in a left occipito-anterior

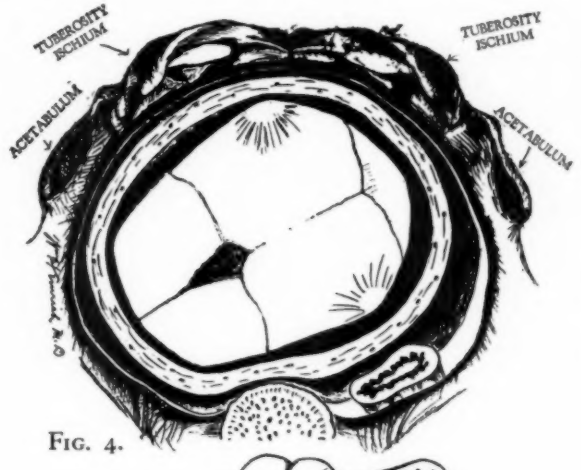

Fig. 4.

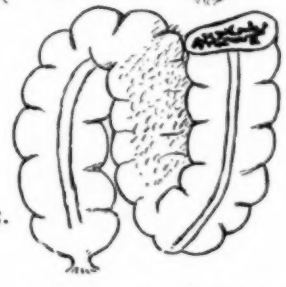

Fig. 5.

Fig. 4. Sigmoid as it crosses pelvic brim; acting as buffer between posterior surface of uterus and pelvic brim, permitting return circulation in and limiting edema in posterior lip of cervix.

Fig. 5. Continuation of sigmoid into true pelvis occupying left side of pelvic cavity, behind left broad ligament; distended it pushes pregnant uterus to right side of abdomen; distended slows up delivery; empty acts as buffer to posterior segment of uterus during labor.

position does not exert the same pressure as the os pubis and the anterior brim of the pelvis. Under these conditions the posterior half of the cervix does not become edematous and thickened, but is thinned out and retracts over the presenting part (Figs. 4 and 5).

In rachitic pelves or any pelvis that does not conform to normal lines, there may be points of pressure posterior that might induce a thickened edematous posterior lip. Likewise I have observed in pelves with a small circular rather than a normal sized oval inlet that the entire circumference of the dilating cervix is nearly the same in thickness.

TECHNIC OF THE ACTUAL REPAIR

Under thorough aseptic precautions, the vaginal tract having previously been

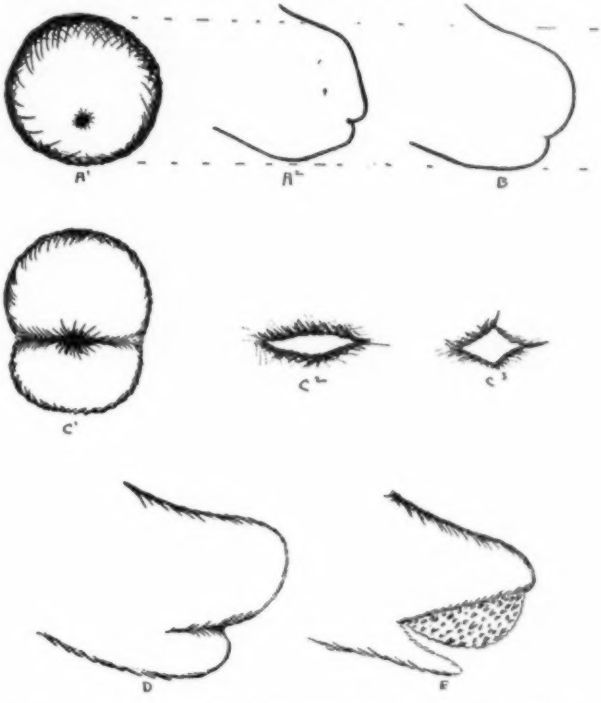

Fig. 6. A^1 and A^2. Non-gravid, non-parous cervix, consistency of art gum. B. Gravid (early) non-parous cervix. Velvety to touch. C^1 Non-gravid multiparous cervix, old healed bilateral tear. C^2 and C^3. Deep tears through internal os. D. Multiparous gravid cervix. Velvety to touch. E. Granuloma (chronic thick granulations) endometrium of bilaterally torn non-gravid parous cervix.

prepared according to indications, namely, if an active vaginitis and cervicitis are present, I advocate and use hychlorite douches one or more days ahead of delivery. As soon as the patient reaches the hospital she is given an enema, shaved, and if indicated a hychlorite douche. Pains are timed, vaginal examination is made, patient is moved to delivery room well in advance of delivery. I do not believe in waiting until the last minute for these reasons: you cannot have your patient under proper control; you do not have time to scrub properly. I want the nurse properly scrubbed up, the sterile goods and instruments properly spread. I do not like haste. Good team work makes obstetrical work just a little less trying.

The pubic region, thighs, buttocks and anal region are painted with mercurochrome solution. Mercurochrome is injected into vagina with bulb syringe or a swab is used.

Patient is delivered under an anesthetic.

If perineum is torn, which it most often is, bleeders are tied and sutures placed but not tied, just fastened with a hemostat. The placenta is delivered. Ergot alone, or combined with obstetrical pituitrin, is given hypodermatically. The anesthetist is asked to watch the fundus.

The post-partum mechanical retractor is placed. There are times when cervical tears bleed profusely. Then the suction pump is used until hemorrhage can be controlled by sutures.

The first tissue presenting is the vaginal surface of the anterior cervical lip, edematous, dark blue, the margins smooth. The gentlest handling serves best because the traumatized cervix is very friable. Using sponge forceps (which are unsatisfactory because sutures are occasionally passed through the fenestra, but because they do less damage than anything else that I have at this time), the cervix is picked up and the margins followed all around until the entire circumference is found.

The posterior lip is retracted, thinned out, irregular and beautifully macerated.

Cervical tears are in the shape of an "L," the end of the lower, the horizontal, bar right at the margin of the os proper. This is true on both sides except that the "L" on the patient's left side is a reversed "L." Interrupted through and through sutures of No. 4 forty day chromic catgut are placed from bottom of tears right up to the os proper. The anterior and posterior lips are carefully approximated. No sutures are drawn tight. I have failed at times to place sutures close enough to the small os. The result in those cases has been very disappointing.

Iodoform gauze strip is placed against cervix and out of vaginal orifice for twenty-four hours.

The judicious administration of flext. ergot is absolutely necessary, drams ½, every two hours, to prevent clot formation,

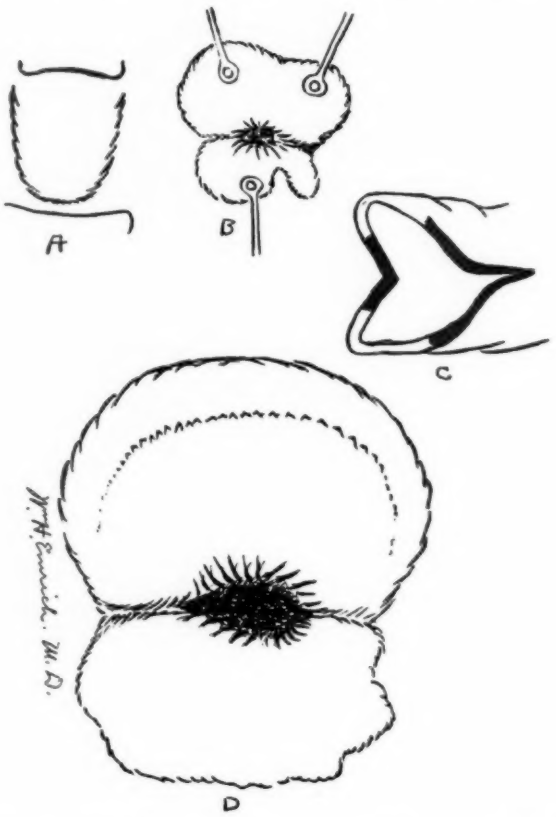

Fig. 7. Primiparous post-partum cervix. A. Vaginal surface of anterior lip, as seen through speculum. B. Method of grasping with sponge forceps. C. Textbook illustration, incorrect. D. Accurate drawing of primarily torn post-partum cervix.

the passage of which would tear out practically all sutures, thereby undoing all our work and efforts.

Occasionally I replace the iodoform gauze if conditions indicate. This can be readily done by drawing patient to edge of bed, placing one foot on bedside table, carefully using bivalve speculum and headlight.

The clinical incubation period for vaginal bacteria is five days. At this time the lochia become offensive. This is the time when lymphatic absorption would be disastrous, repair or no repair. For years I have had post-partum cases douched with hychlorite solution from the fifth day on.

Examine your patient two months later and decide for yourself.

THE IMMEDIATE BENEFITS

There is less post-partum flow; especially is it noticeable that the first twenty-four hour lochia is reduced. In none of our primarily repaired post-partum cases have large vaginal clots been evident.

The lying-in period seems productive of quicker convalescence. There seems to be the same comparative difference between a primarily repaired post-partum case and one not repaired as there is between a thin wiry postoperative patient who is ready to leave the hospital in ten days as compared to the adipose asthenic type hospitalized for twenty-one days.

In other words the morbidity is very definitely reduced.

THE ULTIMATE BENEFITS

Leucorrheal conditions are less likely to result, less troublesome if present and respond more promptly to treatment.

Erosions and excoriations not previously present are less likely to result and if present heal more promptly.

Since 90 per cent of cervical cancers are implanted on lacerated cervices, the primary repair of post-partum cervices is an invaluable prophylactic measure against future malignancy.

SPECIAL OBSERVATION

For several years I have chemically tested the reaction of the cervical mucosa of gynecological patients and find it consistently alkaline. I have likewise at the same time examined the vaginal mucosa and invariably find it acid and sometimes highly acid. An everted alkaline cervical mucosa lying in a pool of acid mucus day in and day out is ultimately destined to undergo inflammatory reaction and organic change, the final results one can readily visualize.

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*Continued from p. 556.

NEW INSTRUMENTS

AN IMPROVED FOOT SUPPORT ATTACHMENT

FOR THOMAS SPLINTS*

GUY A. CALDWELL, M.D.

SHREVEPORT, LA.

ONE of the most annoying difficulties connected with the care of a fracture treated in a Thomas splint is that of maintaining the foot in dorsal flexion. The appliances in general use tend to get out of adjustment frequently or are uncomfortable.

The apparatus illustrated herewith was designed by the writer and has been used on a number of patients for more than a year. It has the proved virtues of simplicity, easy adjustment, stability, comfort, cleanliness and durability and is inexpensive to make.

The apparatus consists of a wooden or celluloid foot piece with a leather strap, two coiled steel wire springs, and two detachable lugs with steel uprights. The foot piece is roughly shaped to the contour of a foot, has a hard leather spur piece behind the heel and a strap attached which passes across the front of the ankle. The contours are such that the foot piece may be used on either foot. In a later model the foot piece has been made of ⅛ in. sheet celluloid, cut to a pattern in one piece, heated and molded on a wooden model. The spring is 9 in. long, of ¼-in. 14-guage steel wire, nickel plated. The detachable uprights are made in two parts, the lower consisting of the slotted lug with a wing set screw, and the upper consisting of a thin blade of 16-guage Sheffield steel, 5 in. long by ⅝ in. wide, the base of which is welded into a shallow slot in the upper face of the lug. The lug is made from cold rolled steel ⅝ in. in diameter by ⅞ in. long, and a slot 5/16 in. wide by 9/16 in. deep is milled in the lug at an angle of 45° with the side. The lower end of the lug is drilled and threaded at the center to receive the wing screw, size 8, 32 threads to the inch. The upright is nickel

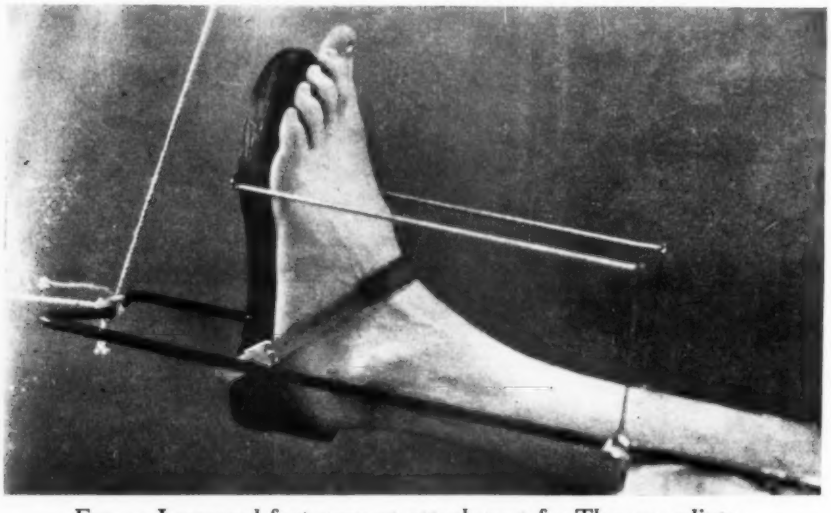

FIG. 1. Improved foot support attachment for Thomas splints.

* Submitted for publication June 23, 1930.

plated and polished. The cost of materials and labor has been approximately $2.50 for each completed foot support.

point to give the foot support with comfort. The moderate elastic tension against the sole of the forefoot is comfortable and

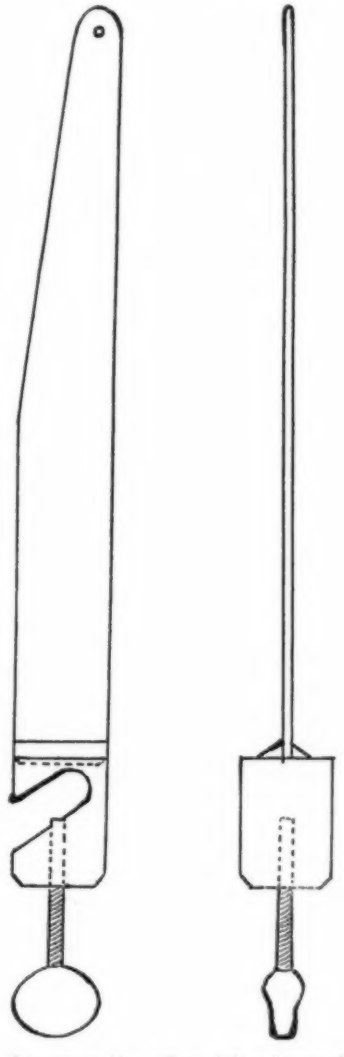

Fig. 2. Construction of uprights (actual size).

When the patient's leg has been suspended in the Thomas splint or Pierson knee flexion attachment, the slings, traction bands and the spreader and weights are adjusted, the foot piece can then be buckled to the foot and the uprights attached to the splint bars at the proper

encourages active exercise but the foot piece stays in place regardless of the direction or amount of ankle motion.

If the apparatus is properly constructed and applied, it does not impinge upon or interfere with any other parts of the apparatus for traction and suspension.

CASE REPORTS

DIVERTICULA OF THE APPENDIX*

PAUL KURT SAUER, M.D.

NEW YORK

THE first definite description of a dilatation of the appendix with a retained mucous or mucoid fluid was by Rokitansky in 1842. Gähtgens spoke of an autopsy finding in 1853, and Virchow in 1863. Rokitansky expressed the opinion, in 1867, that this condition was a colloid carcinoma. Steiner reported, in 1882, that in 2280 autopsies he found 3 cases of hydrops of the appendix. After 1890, when abdominal operations became more frequent, the condition was not so rarely observed; yet Stengel, in 1906, reported having observed but 1 case in 2000 autopsies. Von Bruns, in 1905, was one of the first to describe the pathogenesis of diverticula of the appendix.

The condition, while rare, is common enough to excite interest.

McGrath and MacCarty found 17 diverticula in 5000 appendices (.34 per cent).

Konjetzny found 2 diverticula in 1000 appendices (.2 per cent).

Moschowitz found 4 diverticula in 1500 appendices (.26 per cent).

Mertens found 3 diverticula in 106 appendices (2.8 per cent.)

Stout (Presbyterian Hospital) found in 264 cases operated upon for appendicitis from July 1, 1921 to June 30, 1922, a percentage of 1.89.

At the Lenox Hill Hospital among 5283 appendices examined in the pathological laboratory there were found 9 cases (.17 per cent).

True congenital diverticula are extremely rare, only 1 case being found in the literature, that described by Edel.[1] In this type the walls of the diverticulum retain all the coats intact. There is, in contradistinction to the acquired type, no absence of the muscularis or submucosa at any part of the circumference of the sac. Several cases of congenital diverticula are reported, and if one were to read titles only, one might be misled as to the rarity. However, a perusal of the microscopic examinations by the pathologists soon dispels the illusion.

The acquired types are inflammatory and non-inflammatory in character, of which the former are the more common. The formation of the non-inflammatory type is probably analogous to the formation of diverticula of the colon. That is, they are supposed to be formed by a pouching of the mucous membrane and serosa alongside the artery which passes through the outer coats to the mucous membrane practically at a right angle. This is supported by the fact that the usual location of diverticula is between the leaves of the mesentery. In order for this pouching to occur there must be some pressure exerted in the lumen which forces the mucous membrane through the weakest point. This pressure need not necessarily be of great force, yet it must be constant or frequently repeated, and become increasingly greater as time goes on. One might even venture the opinion that all acquired diverticula are of inflammatory origin, at least indirectly if not directly. I say this, because in order to have this pressure gradually (in all likelihood very gradually: else there would be too much pain) increasing, there must be some blockage to the normal physiological drain-

[1] *Vircbows Arcb. f. patb. Anat.*, 138: 1894.

*From the Surgical Service of Lenox Hill Hospital; Dr. Hermann Fischer. Read before the Surgical Section of the New York Academy of Medicine, April 4, 1930.

age of the appendicular lumen. The most common form would be a cicatrix near the base due to some previous inflammatory process. If the pressure is sufficiently great and forces a small pouch out alongside the artery somewhere distal to the cicatrix, we have a diverticulum which is acquired and non-inflammatory, but indirectly due to a previous inflammatory process proximal to the site of the diverticulum.

Stout endeavored to reproduce this condition experimentally by taking fresh appendices, closing off the lumen at the base around a small tube, and forcing fluids into the lumen under considerable pressure. However, diverticula did not develop. It seems to the writer that conditions as they exist in vivo cannot, in this instance, be reproduced ex corpore. When the appendix is still part of one, there is probably never so great a pressure in the lumen, and, experimentally, this pressure can be maintained for only a comparatively short time. It is easy to conceive that slight pressure, exerted constantly, or frequently repeated, over a considerable period of time, and gradually increasing in intensity, will weaken the muscular coat at the point of perforation of the artery to such an extent that a pouch of mucous membrane would protrude.

The inflammatory type always follows some previous inflammation of the appendix. At one of the sites of a local inflammation in the lumen of the appendix the muscularis is weakened or destroyed. The mucosa heals from the edge toward the center and prevents the reunion of the muscle coat. A probable reason why this condition does not occur more often is the variation in the ratio between the amount and rapidity of necrosis and repair. At the same time, or at a later attack, somewhere proximal to this point, there is considerable destruction with the subsequent formation of an annular cicatricial constriction, causing either a partial or complete occlusion of the lumen. We then have a blind sac formed by the distal portion of the appendix, the intra-appendicular mucocele. The mucous membrane in this portion still secretes, the pressure becomes increasingly greater, the weakest point is at the site of the previous inflammation, the mucosa is pushed out, and we have a pouch composed of mucosa, serosa, submucosa, and in only a part of the wall is there any muscularis; in other words, a pseudodiverticulum. The contained fluid may burrow between the coats of the appendix, and if a cross section of this apppendix be made we get a picture of a double lumen, only one of which will have a muscular coat for part of its circumference.

If the cicatrix at the proximal portion of the appendix causes a complete blocking of the appendicular lumen so that absolutely no fluid can escape into the cecum, and neither can any colon contents flow the other way, the fluid contained in the distal portion soon becomes sterile and gelatinous. The diverticulum may leak, and some of this fluid run between the leaves of the mesentery. If the patient be operated upon at this stage a condition will be found which has been described as extra-appendicular mucocele. Going only a step further we can visualize this fluid getting into the peritoneal cavity. As this fluid is not irritating, and some secretion still persists from small portions of mucosa, a large amount may collect before the patient's symptoms become severe enough to require operative interference. The condition now is what is usually termed a pseudomyxoma peritonei.

In looking through the literature we found many terms used to describe various conditions: such as, hydrops of the appendix, mucocele of the appendix, together with the different terms mentioned before. It is the opinion of the writer that the mechanism for the formation of all these conditions is the same as that for the formation of diverticula, and that these terms are merely names for slightly different phases of the same pathological condition.

Clinically these cases are practically never diagnosed before operation. The patients are usually operated upon for acute or chronic appendicitis. There is, however, one significant point in the history that might lead one to suspect the possibility of a diverticulum being the underlying factor in the ailment. This is a slow onset. In some cases the patient will complain of a slight feeling of discomfort in the right lower quadrant, or even slight recurrent attacks of pain over a period of weeks or months, and yet not severe enough to cause cessation of work. Gradually these pains become more severe, so that at last a picture of acute appendicitis is presented. This type of history will be more often elicited in private cases than in the usual ward case.

REPORT OF CASES

Case 1. T. B. (18578) Male, forty-five years of age. Patient admitted to Lenox Hill Hospital on March 15, 1928 complaining of abdominal pain and vomiting for three days prior to admission. The pains were at first vague and not localized to any portion of the abdomen. On the second day they were localized to the right lower quadrant and did not radiate. Vomiting set in. His past history is negative except for typhoid in 1907. The physical examination was unimportant except for the rigidity over McBurney's point, and rebound tenderness. Temperature on admission 100.2°F., pulse 98, respirations 24. The urine showed 2+ albumin, and hyaline and granular casts. Blood count was not done.

Operation: Kammerer incision. The appendix lay in the inferior ileocecal fossa, much thickened and infiltrated, and covered with fibrin. The tip was ruptured and there was free pus. Typical appendicectomy with two cigarette drains, one to the stump and the other into the pelvis.

Pathological Report by Dr. Bullock (Laboratory No. 23658): The specimen consists of an appendix 5.5 cm. by diameter proximal 0.6 cm. by distal 1.2 cm. The surface is covered with thick fibrinous exudate, disclosing after removal a blackish-blue serosa. The distal 1 cm. is thickened and bent, and shows several elevations on its surface. The lumen in the proximal end is obliterated, but in the remaining four-fifths of the organ it is dilated and filled with gray black material. The walls are thickened. There are four diverticula leading into the thick inflamed mesoappendix. *Microscopic:* Sections of the appendix show extensive necrosis, associated with a generalized purulent infiltration. In areas the necrosis involves all the layers of the wall. Sections through the mesoappendix at right angles to the diverticula show the latter to be lined with mucous membrane outside of which is a large amount of muscle which in places show distinct longitudinal and circular coats. The mucous membrane of the diverticulum shows varying degrees of necrosis and the surrounding tissue is infiltrated with many cells.

Patient made uneventful recovery, and was discharged on April 6, 1928.

Case 11. E. O'F. (18476) Female, aged twenty, telephone operator. The patient does not complain of any subjective symptoms, nor can any objective ones be elicited. She has had two attacks of appendicitis, one in 1923 and one in 1927. At the last attack there was generalized abdominal pain, which became cramp-like, and localized in the right lower quadrant. Two months ago she was advised to submit to operative interference. The physical examination was absolutely negative. The urine was normal. Temperature 99°F., pulse 82, respirations 20. The diagnosis of chronic appendicitis was made from the history.

Operation, March 8, 1928: Kammerer incision. Numerous adhesions were found in the cecal region. The appendix was retrocecal and adherent. There was a large movable stone in the proximal half. After the appendix was delivered, it was found to be in two segments, the distal portion having been spontaneously amputated. The ends of the lumen were closed and the segments adherent to each other by a small band of fibrous tissue. Appendicectomy *ad secundam artem.*

Pathological Report by Dr. Bullock (Laboratory No. 23607): Specimen is an appendix 3.2 cm. by 1 cm. The serosa is roughened, dark brown, and dull. The lumen is very large and contains a hard brown fecalith. The walls are very thin and fibrous in texture. There is an almost entire disappearance of mucosa. There is in the mesoappendix a small oval mass 1 cm. long which seems to be partially calcified

with a central greenish area, and a tough fibrous peripheral section.

Microscopic: Section of the appendix shows

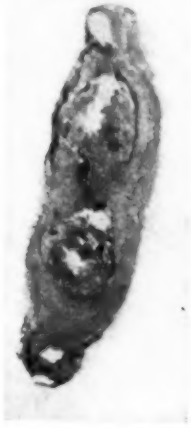

Fig. 1. Four diverticula in one appendix.

dilatation of the lumen and atrophy of the wall involving chiefly the mucosa and the lymphoid tissue. The former appears to be everywhere intact though extremely thinned out in places. There is a localized fibrous thickening of the serous coat, associated with extensive hemorrhage. Section of the nodule from the mesentery shows circumscribed appendicular tissue including all the coats. In one place there appear to be two distinct lumina, each bordered by intact mucous membrane and apparently possessing separate and distinct submucous and muscular coats. Several isolated gland tubules are noted in the submucosa. The lumen contains amorphous material showing deposits of lime salts. The wall is sclerotic, and the surface is thickened by fibrosis and shows hemorrhagic fibrous adhesions. The sequestration of this mass of appendix in the mesentery is probably explained by spontaneous amputation of a diverticulum.

The patient was discharged after an uneventful recovery on the tenth day.

Case III. A. C. (18807) Female, aged twenty-nine, nurse-girl. On admission, April 7, 1928, the patient complained of pain in the right lower quadrant of one day's duration. The pain began the night before admission, and was accompanied by constant nausea, but no vomiting. She had had one similar attack six months previously, at which time she had vomited several times. Other history was negative. The physical examination revealed nothing except tenderness over the entire lower abdomen, most marked over McBurney's point. There was distinct rebound

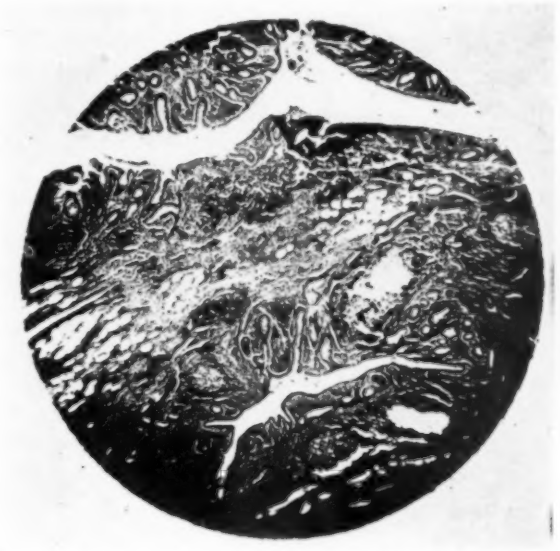

Fig. 2. Portion of appendix shown in Figure 1, showing double lumen.

tenderness, but no masses palpable. Vaginal examination was negative except for tenderness in the right fornix. Blood count showed 14,200 white cells with 72 per cent polymorphonuclears. The urine was negative. Temperature on admission 100.8°F., pulse 88, respirations 20.

Operation on April 9, 1928: Kammerer incision. The appendix lay retrocecal, embedded in thick adhesions. The base was free. Appendicectomy *lege artis*. A small drain was inserted.

Pathological Report by Dr. Bullock (Laboratory No. 23804): Specimen consists of an ovoid mass 7 cm. by 4 cm. The external surface is brown and granular. The cut surface shows a lumen surrounded by a gelatinous, yellowish-white tissue, with an area of liquefaction adjacent to the lumen previously described.

Microscopic: Sections of the appendix show marked thickening of the wall, due partly to fibrosis and inflammatory exudate, and partly to hyperplasia of the muscular coat. One section presents a lumen which is bordered by an intact mucous membrane, the glands of which are large and rich in goblet cells. This is bordered on one side by the submucosa, muscularis and serosa. The muscularis is very irregular, and in one place encloses a mass of fibrous tissue, which may possibly represent

an obliterated lumen. At a point where there is a break in the muscularis, there is a second lumen, one side of which is bordered by mucous

Fig. 3. Three illustrations of diverticula from different appendices.

membrane showing large areas of necrosis and suppuration. The other side of the lumen is bordered by a thick mass of fibrous tissue containing strands of smooth muscle. The greater part of the tissue is transformed into myxomatous tissue which shows areas of necrosis and suppuration. Near one surface of the appendix there is a sacculated gland tubule lined with cylindrical cells and embedded in fibrous tissue. The fibrous tissue is almost completely surrounded by smooth muscle showing a suggestion of a circular coat. The outer surface of the appendix shows areas of necrosis, suppuration, and fibrinous exudate.

The patient was discharged, cured, on the fourteenth day.

Case iv. H. A. (21178) female, aged forty-two, housewife. The patient was admitted to the hospital on December 3, 1928 complaining of vomiting and abdominal pain for the past forty-eight hours. She had had no previous similar attacks. During the first twenty-four hours she vomited four times, and had had rather loose bowels. No vomiting occurred during the second twenty-four hours, but she felt severe drawing pains in the umbilical region. Her previous history was irrelevant. Menses had always been regular and painless. Physical examination revealed a rather fat distended abdomen. There was marked redness over the lower abdomen due to a hot water bottle. In this portion there was definite

Fig. 4. Sections of appendix at two different levels, with diverticulum shown at left.

tenderness, most marked over McBurney's point. Rigidity was lacking. Vaginal examination was negative except for tenderness in the right fornix. No other pathological findings were elicited. Admission temperature, 101.2°F., pulse 114, respirations 24. The urine was normal. Wassermann reaction, negative. The patient came to operation for acute appendicitis. An appendicectomy was done in the usual manner except that the stump was not buried. At operation the appendix was found to lie in the retrocecal position, curled up, and held by firm adhesions.

Pathological Report by Dr. Bullock (Laboratory No. 24998): Specimen consists of an appendix measuring 8 cm. in length and 0.8 cm. in diameter, somewhat dilated at the tip. The surface is rough, deeply injected, and covered with a grayish exudate and adhesions. At the tip it is covered by dark hemorrhagic areas and is edematous. The lumen is patent throughout and is filled with fecal matter. The mucosa in the proximal portion is thickened, while in the distal extremity it is thinned, hemorrhagic and necrotic. *Microscopic Examination:* Section of the distal part of the appendix shows extreme necrosis which is confined to the inner layers of the wall. The necrosis is associated with purulent infiltration and extensive hemorrhages. The lumen is extremely dilated and in one area shows a false diverticulum. Section through the proximal part shows fibrosis of the wall and necrotic patches in the inner layer.

Case v. J. G. (P2808) male, aged thirty-two, contractor, was admitted to the hospital on November 28, 1928 complaining of pain in the right lower quadrant of sufficient intensity to cause his ceasing work, but not severe enough to keep him from walking around.

For the last two years he had noticed similar pains at more or less irregular intervals. One year ago, during one of these attacks, a physician had made the diagnosis of appendicitis. Ice bags applied to the abdomen relieved him for the time being. From that time he had had occasional days when he felt sick, but, as he says, "nothing serious." Physical examination revealed a man 5 ft. 7 in. tall, weighing about 195 lb., and too fat. He was sick enough to be petulant, but not, apparently, acutely ill. Heart and lungs were negative, the abdomen protuberant. Between the umbilicus and the anterior superior spine a definite mass, the size of an orange, could be palpated with ease. There was marked rigidity on the right side. Rectal examination was negative. The urine showed 3+ albumin, and hyaline and granular casts. Blood count was not done. Admission temperature 103.2°F., pulse 128, and the respirations were 28. Immediate operation for acute appendicitis with localized peritonitis and abscess formation.

Operation: Kammerer incision. On opening the peritoneum a mass of highly inflamed omentum was found surrounding the caput coli. On freeing this omentum, about 10 c.c. of pus escaped into the wound. Below the omentum was found a highly inflamed, infiltrated hard mass with many adhesions, which gave one the impression that it might be tuberculous, carcinomatous, or actinomycotic. With considerable difficulty the tumor was freed, and finally an appendix was shelled out of the mass. The base of the appendix was an inch in diameter, and the form much distorted. The lumen was very small, but the walls were at least half an inch thick. Appendix removed, drainage tubes inserted, and the abdomen closed in layers to the drains. On the ninth day a secondary abscess had formed which was evacuated by inserting the finger through the drainage canal and in between the retaining loops of intestine. A fecal fistula developed, but otherwise there were no complications in the convalescence.

Pathological Report by Dr. Bullock (Laboratory No. 24967): Gross appearance: The specimen, received in formalin, consists of an appendix and a mass of inflammatory tissue. It measures 6 × 5 × 3 cm. *Microscopic:* Section through the mass reveals an appendix containing two rather large and apparently separate lumina bordered by mucous membrane. The entire wall is greatly thickened by fibrosis and the products of an acute and chronic exudative inflammation. In one area there is a large and ill-defined abscess. Elsewhere the wall is richly infiltrated with small round cells. Throughout the wall are numerous small hemorrhages. Attached to the appendix is a mass of inflammatory fat tissue.

Case vi. W. F. M. (P1973) male, aged forty-two. The patient was admitted to the hospital on April 14, 1928 complaining of pain in the right lower abdomen. Two days previous to his admission he was seized with generalized abdominal pains, not radiating, but later localizing in the right lower quadrant. No vomiting or other symptoms. His bowels have been moved with laxatives. No urinary symptoms. The pain has been getting progressively worse, and today he had pain when walking and difficulty in standing up. His previous history is negative except for typhoid fever many years ago. He has never had a similar attack. The physical examination revealed nothing outside the abdomen. The abdomen was not distended, and there was no generalized tenderness or rigidity. At McBurney's point there is some rigidity, and in this area a hard tender mass is palpable. Rectal examination is negative. Urine normal.

Operation: Kammerer incision. There was no free fluid on opening the peritoneum. A tumor, almost grizzly hard, was found in the region just below the cecum, and forming part of the cecal wall. The surrounding tissue, especially the mesentery of the lower ileum, was thickened and hard. With difficulty this mass was entered and about 2 oz. of thick yellow pus was evacuated. It was difficult to make out the appendix because of the matting together of the tissues. The appendix was removed but the stump could not be inverted on account of the infiltration. Two drains were inserted. Closure in layers to the drains.

Pathological Report by Dr. Bullock (Laboratory No. 23850): The specimen, received in formalin, is an appendix 5 cm. in length by 0.8 cm. in diameter. The whole appendix is covered with organized exudate and fat to such a degree that the original organ can only be seen on section. The lumen appears to be obliterated. The walls are thick and tough. *Microscopic:* Sections of the appendix show a generalized overgrowth of fibrous tissue and two large areas of fatty infiltration. All epithelial structures are missing, and the

lumen is obliterated by granulation tissue. The lymphoid tissue shows localized hyperplasia. The wall is irregularly infiltrated with inflammatory cells. Outside of the muscular coat there is a large abscess bordered by granulation tissue, to one side of which is a well-defined, though irregular, second muscular coat.

The patient was discharged, cured, on May 24, 1928.

Case vii. M. J. (20447) female, aged thirty-eight, housewife. The history is irrelevant so far as the appendix is concerned. She was operated upon for bilateral salpingo-oophoritis, and the appendix was removed incidentally. Equally unimportant, from our standpoint, is the physical examination.

Pathological Report by Dr. Bullock (Laboratory No. 26835): The specimen, received in formalin, consists of an appendix, measuring 6 cm. in length by 1.3 cm. in diameter. The peritoneal surface is covered by torn fibrous adhesions and hemorrhages. On section the lumen is patent throughout, and empty. The mucosa is thickened, but shows no gross lesion. The wall is thickened by an increase in fibrous tissue, and contains small hemorrhages. *Microscopic:* Sections of the appendix show the wall to be thickened by a more or less generalized overgrowth of fibrous tissue and hypertrophy of the muscle coat, and is infiltrated with inflammatory cells. These cells are rather few in number, except in the thickened outer coat where they are abundant and consist largely of small round cells. Attached to the outer surface are inflammatory fibrous adhesions. The lumen is, for the most part, of small caliber, and in one place the epithelium bordering it is eroded away. The mucous membrane in this area is atrophic and shows an increase in fibrous tissue. The lymph follicles are moderately hyperplastic. In one part of the organ there is a small round canal which is directed perpendicular to and communicates with the lumen. This canal passes through all the coats and forms a nodule on the outer surface where it is slightly dilated and covered with thickened serosa. It is surrounded by mucosa and submucosa, though in one area the mucous membrane is eroded away. There is no marked inflammatory reaction about this false diverticulum.

Case viii. C. B. (19157) female, aged forty-three, housewife. The history, so far as the subject in hand is concerned, is irrelevant. She was operated upon, primarily, for a fibroid of the uterus. The appendix was removed at the same time. The physical examination revealed nothing abnormal about the appendix.

Pathological Examination by Dr. Bullock (Laboratory No. 23964): The appendix is 5.5 cm. in length by 1 cm. in diameter. Its outer surface is slightly congested. On incision its walls seem thicker than normal, though they do not appear inflamed. The mucosa is glistening throughout, but it is somewhat corrugated and also seems thicker than normal. The lumen is patent throughout.

Microscopical: Sections of the appendix show a narrow lumen bordered by an intact mucous membrane. The lumen is eccentrically placed, and one of the sections shows a second lumen incompletely lined with mucous membrane. The remainder of the wall shows fibrosis, fatty infiltration of the submucosa, and hypertrophy of the muscularis. The lymphoid tissue is very scant and there is but little cellular exudate.

COMPLETE ACCIDENTAL CUTTING OF URETER DURING LAPAROTOMY

WITH NON-SURGICAL ANASTOMOSIS; REPORT OF CASE*

FREDERICK T. LAU, M.D., F.A.C.S.

NEW YORK

REALIZING the frequency with which ureters are accidentally tied and cut during laparotomy, my only excuse for reporting this case is its unusualness.

CASE REPORT

Patient M. D. Female aged thirty-two. Negress, admitted to the Gynecological service November 21, 1929, with provisional diagnosis of salpingitis and oophoritis. After several days she showed signs of ruptured ectopic pregnancy. Her blood picture on December 2 was as follows: erythrocytes, 1,356,250; leucocytes, 26,400; hemoglobin, 32 per cent, blood Wassermann reaction 4+. Repeated urinalyses showed 2–4+ albumin, also many hyaline and granular casts and many clumped pus cells. She was transfused and on December 3, under general anesthesia a celiotomy with removal of products of pregnancy was done as follows:

"Midline incision. Before opening peritoneum, dark blood could be seen through it. Peritoneal cavity was filled with large blood clots. The right tube was enlarged and ruptured at one point from which emerged a cord attached to a fetus about 9 cm. long; the other end of the cord was attached to a mass of placental tissue about 5 cm. in diameter. There was considerable fresh bleeding from the open tube. Tube was clamped at its proximal end, vessels ligated and divided. There was free bleeding in the form of oozing from the site of the placenta. This could only be controlled by packing with gauze. In freeing the distal end of the tube the ligature was put around a mass of tissue in which, after the tube was amputated, what appeared to be the cut end of the right ureter was visible. At this time patient's condition was so serious that no attempt could be made to repair the ureter. Proximal end was brought down and sutured to the extreme head of the distal end. Rubber dam drain was placed down to the end of the ureter. Two gauze packs were left in place to control hemorrhage. Wound was quickly closed in layers and the skin with interrupted silk worm gut."

Patient's condition at the end of operation was poor. Patient's blood pressure immediately prior to operation was 94/50

Pathologist's Report:

Gross: The specimen consists of an irregular and nodular tube adherent to its associated ovary and having firm thickened walls. There is also an embryo 5 cm. long.

Microscopic: Sections show a chronic nonspecific inflammation of tube and ovary.

Diagnosis: Salpingitis, chronic. Oophoritis, chronic. Embryo.

The immediate postoperative convalescence was very stormy and considerable stimulation was necessary.

The patient was first seen in consultation by the writer on January 3, 1930 at which time cystoscopy and urography were requested. The patient presented a healing, slightly infected wound in the right midline from which a small amount of urine was oozing. Upon questioning the interns and nurses, the impression was gained that the dressings did not contain the entire output of urine from the right kidney and that at least a fair percentage of urine from this kidney was finding its way to the bladder. In view of these findings, it was felt that any ureteral instrumentation at this time would disturb whatever ureteral anastomosis was in progress. The daily fluid intake and output were recorded and it was observed that the percentage of the latter was constantly increasing. The wound continued to heal and decrease in size and on February 10 was entirely healed and dry.

Cystoscopy was done on February 18, as follows: Usual preparation. There was some obstruction to the passage of the cystoscope due to constriction of the urethra. Bladder mucosa and landmarks normal with the excep-

* From the Urological Service of Grasslands Hospital. Read before the Genito-Urinary Section of the New York Academy of Medicine, May 21, 1930.

tion of pouting at each orifice at the time of efflux. A No. 6 catheter passed to the left kidney pelvis without obstruction. On the right side there was a definite obstruction at the junction of the middle and upper third and the catheter would pass no further. Sterile specimens collected from bladder and both kidneys for urea and microscopic examination. One cubic centimeter phenolsulphonephthalein intravenously appeared on the right side in five and one-half minutes and on the left side in and four one-half minutes. Pyelogram and ureterogram done on the right side.

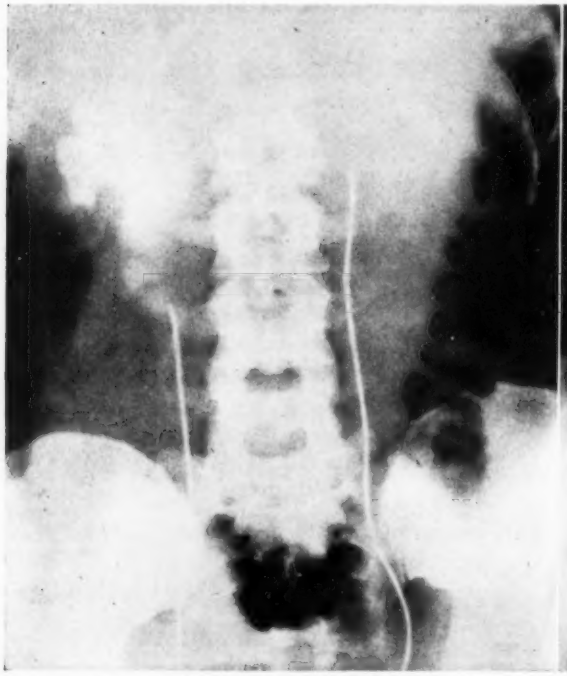

Fig. 1. Pyelogram of right kidney (Feb. 8, 1930) showing lead catheter on level of fourth lumbar vertebrae and marked hydronephrosis of right kidney.

Fig. 2. Right ureterogram showing alternate constriction, dilatation and kinks with right angle kink and hairline outline of ureter over transverse process of fifth lumbar vertebra, where anastomosis probably occurred.

Laboratory Findings:

Feb. 19, 1930	Bladder	Right kidney	Left kidney
Urea.....	.....	.0048	.0063
Micro.....	Occ. pus cell	Few pus cells	Few pus cells
	Occ. epithelial	Few epithelial	Few epithelial
Stained preparation	No organisms	No organisms	No organisms
Culture.....	Sterile	Sterile	Sterile
P. S. P.....	.....	12 c.c.	15 c.c.
		No P. S. P.	3 per cent P. S. P.

Radiographic examination of the urinary tract shows opaque catheters in situ. The tip of the right catheter is seen on a level with the transverse process of the fourth lumbar vertebra. After the injection of contrast material in the right side, the major calyces of the right kidney appear considerably dilated as does the upper portion of the ureter contiguous to the pelvis. Contrast substance is seen in what appears to be the right ureter which structure is dilated and shows numerous kinks.

The patient insisted on leaving the hospital before dilatation of the right ureter could be accomplished and the social service department was unable to locate her subsequently.

CONCLUSIONS

1. The present picture of a markedly hydronephrosed almost functionless right kidney with constrictions and kinks of the right ureter may have been present, to some degree, prior to operation because of pressure from salpingitis and ectopic pregnancy.

2. The extremely poor condition of patient at time of operation precluded any attempt to repair ureter at that time.

3. The partial ureteral anastomosis which had apparently taken place when patient was first seen by the writer, contraindicated any surgical procedure or intraureteral instrumentation at that time.

4. A conservative attitude of watchful waiting was well rewarded with this patient.

5. The degree of ureteral constriction at the site of anastomosis is perhaps no greater than the amount which would have resulted from surgical repair.

BENIGN TUMORS OF THE HEPATIC FLEXURE*

Antonio Ramos Martinon, M.D.

HAVANA, CUBA

THE following case presents considerable interest because of the rarity of benign tumors in the colon and especially because of the difficulty of differential diagnosis in this instance.

Fig. 1. Twelve hours after opaque meal, showing large filling defect in hepatic flexure of colon.

Fig. 2. Twenty-four hours following opaque meal. Note small intestine is not yet empty.

CASE HISTORY

On April 26, 1930, there entered the surgical service of the Canaria Association of Cuba under the care of Professor Duplesis, Mr. R. S., forty-six years of age, white, married. The family history of this patient lacks importance. Aside from the eruptive diseases of childhood, the patient has suffered from malaria and gonorrhea. In 1923 he was operated on for appendicitis.

Several months before entering the hospital he commenced to suffer from painful crises in the right upper quadrant, with obstinate constipation, for the relief of which the patient used purgatives and laxatives. His weight fell off slightly.

* Submitted for publication October 16, 1930.

FIG. 3. Filling defect shown by enema.

FIG. 4. Same defect shown following attempt to evacuate barium enema.

FIG. 5. Photograph of the specimen removed.

FIG. 6. Photomicrograph of specimen, reported by the pathologist, Professor Ramirez Coria, as indicating benign lesion.

The cause of his entry into the hospital was an acute crisis with abdominal distension, meteorism, pain on palpation and fever, all these symptoms indicating an intestinal obstruction. This was relieved by ice bags, hydric diet and rest. As soon as the patient commenced to eat again, the picture of obstruction was repeated, presenting the syndrome of Czenick. The patient felt that gases on reaching the hepatic flexure of the colon were detained and passed backward toward the cecum, until after various attempts the gas boluses did pass with a gurgling noise.

On examining the abdomen by palpation there was noted a zone of resistance in the right upper quadrant, with marked pain on pressure. The examination of the urine and fecal matter gave normal findings. Wassermann and Von Pirquet reactions were negative.

X-Ray Report: Signs of intestinal obstruction due to an intrinsic tumor of the hepatic flexure of the colon. A number of roentgenograms were made following introduction of opaque material by mouth and by enema: the first at twelve hours, the second at twenty-four hours, the third by enema and the fourth following the first evacuation after the enema.

In view of the findings of the *x*-ray study and of the clinical examination carried out by the surgeon, operative intervention was decided upon. A hemicolectomy was done in one stage.

Pathological Report: The resected specimen was sent to the Laboratory of Pathological Anatomy of Professor Ramirez Coria, who gave the following report:

"Segment of colon surgically removed. The organ was received without opening it; so it was possible to determine that one of the ends gave the impression of normal conditions as to thickness of wall, lumen, etc. The other end, on the contrary, showed very thickened walls, the lumen of which was almost completely abolished. A longitudinal section made to observe the interior of the intestine showed that in the segment where the lumen was obstructed the appearance of the mucosa was roughened, full of fissures and excrescences, marked with detritus and mucus. The consistency of these excrescences was fragile. Histological study made at various points showed that the general lesion, which attacked almost equally the whole extent of the organ in its diseased portion, was a papilloid proliferation of epithelium and of the connective tissue, with abundant atypical calciform elements. Between these formations there were observed ulcers, with mucoid necrotic base, invading even to the muscular coat. The remainder of the wall seemed full of miliary foci of infiltration with round cells and mononuclear and polymorphonuclear leucocytes.

There were no signs of malignancy," (Figs. 5 and 6).

CONCLUSION

At times the interpretation of tumors of the hepatic flexure is made difficult from the standpoint of deciding as to their nature. In spite of the carcinomatous aspect of this tumor from the standpoint of the roentgen findings, we refrained from making a diagnosis of carcinoma, limiting ourselves to calling attention to the presence of a tumor of intrinsic origin, without specifying this origin as benign or malignant.

BENIGN PAPILLOMA OF THE RENAL PELVIS*

FRANCIS N. KIMBALL, M.D.

NEW YORK

A.D. an Italian, aged sixty-two, occupation, carpenter. Admitted to the Urological Department of the James Buchanan Brady Foundation on November 18, 1929, at which time he was complaining of pain in the left flank.

Venereal Infection: Denies infection.

Present Illness: Began one year ago with a dull aching pain located in the left costal vertebral angle from which it radiated to the left flank and to the left testicle. The pain was characterized as being sticking. The attacks are periodic and are occasionally accompanied by blood in the urine. Sometimes the pain was so severe that it was necessary for his family physician to give him morphine to relieve the pain. During the past few months the attacks have been more frequent and the pain has been more severe. He thinks that the blood has increased both in amount and in frequency. The last attack occurred one week ago at which time there was a large amount of blood in the urine. During this attack he had severe pain whenever he voided his urine. This caused him to go to a hospital for advice and treatment.

Physical Examination: Reveals a well-developed and well-nourished male of sixty-two years of age. The examination was normal with the following exceptions: There is tenderness in both flanks, but most marked in the left flank, especially towards the left costal vertebral angle. The prostate was slightly enlarged, elastic in consistency and not fixed.

Cystoscopic Examination: Usual preparation. Instrument passed without difficulty. Vesical fundus shows some general edema. Ureteral orifices normal. Vesical orifice shows marked edema. Catheters No. 6 French passed to the kidney pelvis on each side. Specimens collected, sent to the laboratory for culture, urea and microscopical examination. One cubic centimeter of phenolsulphonephthalein injected intravenously, appeared on the right side in four minutes; left side in five minutes. Total amount secreted ten minutes after appearance time, 6 per cent right side, 5 per cent left side.

X-rays taken before and after the injection of sodium iodide into the left kidney pelvis, patient being in the prone and erect posture, catheter withdrawn in the erect posture and ureterogram taken. After the *x*-rays had been completed the catheter was reinserted and sodium iodide allowed to drain off kidney pelvis irrigated with sterile water.

X-ray Examination: Genitourinary tract. Right kidney shadow is small in size and in good position. Left kidney shadow is large in size and gives one the impression that is about twice the size of the right kidney. There is no shadow indicative of stone in the urinary tract. Left pyelogram shows a filling defect which is quite extensive. It is about the size of the terminal phalanx of the thumb. The calices are not badly distorted. The pelvis is enlarged to about three times the usual size. There is a distortion of the ureter opposite the fifth sacral foramen.

Impression: The left kidney is the site of a papillomatous tumor intruding into the left kidney pelvis.

Suggestion: That the left kidney be removed under regional anesthesia.

Operation: Performed under paravertebral anesthesia on November 19, 1929. Usual lumbar incision was made through the superficial fat, extending through the abdominal muscles and fascia, exposing the peritoneum. The peritoneum was pushed upward towards the midline and the incision extended slightly downwards and forwards. The perirenal tissues were grasped with forceps and separated between the forceps exposing the surface of the kidney. The kidney was freed from the surrounding tissues by blunt dissection. When the pelvis of the kidney was exposed, a soft resilient mass was palpated in the kidney pelvis. This mass was freely movable in the kidney pelvis. In view of the findings of the pyelogram, the pelvis was not opened and a nephrectomy was done. Kidney pedicle doubly ligated in the usual manner. Closure with plain catgut, rubber tissue drain from the upper angle of the wound which was closed in layers. Dry dressing, patient returned to the ward in good condition.

The wound healed satisfactorily and was entirely closed at the end of two weeks.

* Read before the Genito-Urinary Section of the New York Association of Medicine, May 21, 1930.

During his stay in the hospital his convalescence was uncomplicated, and he was discharged from the hospital, as cured two weeks after operation.

Pathological Report: The gross specimen consists of a kidney about normal size. It measures $11 \times 5.5 \times 4.5$ cm. in size. It is firm in consistency. The capsule strips with difficulty. The pelvis and attached 3 cm. of ureter are dilated apparently by pyelography. There is no obvious inflammation. On incision of the pelvis it is found to be filled with a soft papillary growth of which no point of attachment is found in this incision. When the kidney substance is cut through the point of attachment is found to be by a broad base at the brim of the pelvis. Microscopic section shows numerous villi of loosely connected tissue covered by a many-layered epithelium, composed of ovoid cells which are regular in size and shape. The loose connective tissue stalks are infiltrated with round and polynuclear cells. No mitoses are found. There is no evidence of any infiltration whatever at the base of the growth, although the base is included in this section. In view of this and also of the regularity of the cells, we believe the process to be entirely benign.

Patient was last seen on May 19, 1930, at which time he was free from symptoms and was enjoying the best of health. Cystoscopic examination reveals that the vesical fundus is normal in appearance; there is no evidence of tumor, stone or diverticulum. Left ureteral orifice is open, golf-hole in type and there is a ureterocele at the lower border of the ureter which remains constant as long as there is pressure in the bladder. The lower end of the right ureter was apparently within normal limits.

TRAUMATIC AVULSION OF THE TIBIAL TUBERCLE

REPORT OF A CASE SHOWING HEALING BY FIBROUS UNION*

BENJAMIN GOLDMAN, M.D.

ERIE, PA.

TRAUMATIC avulsion of the tubercle of the tibia is a distinct clinical entity. After a search of the literature one is struck by the paucity of cases recorded in both American and foreign journals. Cotton[1] points out the rare occurrence of this injury in adults. This condition must be differentiated from the sprain described by Osgood and Schlatter and since known as Osgood-Schlatter disease, a process of gradual onset, occurring most frequently during the age of adolescence and characterized by swelling, tenderness and pain in the region of the tubercle of the tibia. Grossman[2] and others have pointed out that this condition is somewhat analogous to Perthes' disease.

Ossification of the epiphysis of the tibial tubercle takes place most frequently between the twelfth and the fifteenth year. Complete bony union between the epiphysis and the shaft of the tibia does not occur until about the eighteenth year. Rickets predisposes to separation of this process. Trauma, direct and indirect, of varying forces may produce this condition on account of the exposure of the tubercle to these forces.

Avulsion of the tibial tubercle may be the result of direct violence, as in a case reported by Overlock[3] in which the patient sustained a blow just below this process from the hoof of a horse; or as a result of violent contraction of the rectus femoris which apparently was the modus operandi in the case which is reported in this article. The history and physical signs should aid the examiner in making the diagnosis. The patient, as in this case, stepping downward from sidewalk to street, with the weight of the body thrown forward, suddenly loses his balance, and

* Presented before the Staff of Hamot Hospital, Erie, Pennsylvania, October 8, 1929.

in attempting to regain his poise, extends the leg forcibly upon the thigh bringing into play a marked contraction of the rectus femoris. As a result of the quick tearing of the tubercle from the bone, plus the loss of equilibrium, the patient falls and upon attempting to rise finds that it is impossible for him to extend his leg except by very extreme effort and then only with much pain. Subsequent pain is present only upon movement of the affected part and as soon as the limb is immobilized the patient is comfortable. Disability is limited to extension which can be done only upon extreme exertion, the non-affected vasti being brought into use. The swelling in this case was considerable, the knee being puffed out, giving one the impression of an effusion into the joint. Aside from this, there is no deformity. There was exquisite tenderness in the case reported by the writer, the patient objecting very strongly to even light palpation.

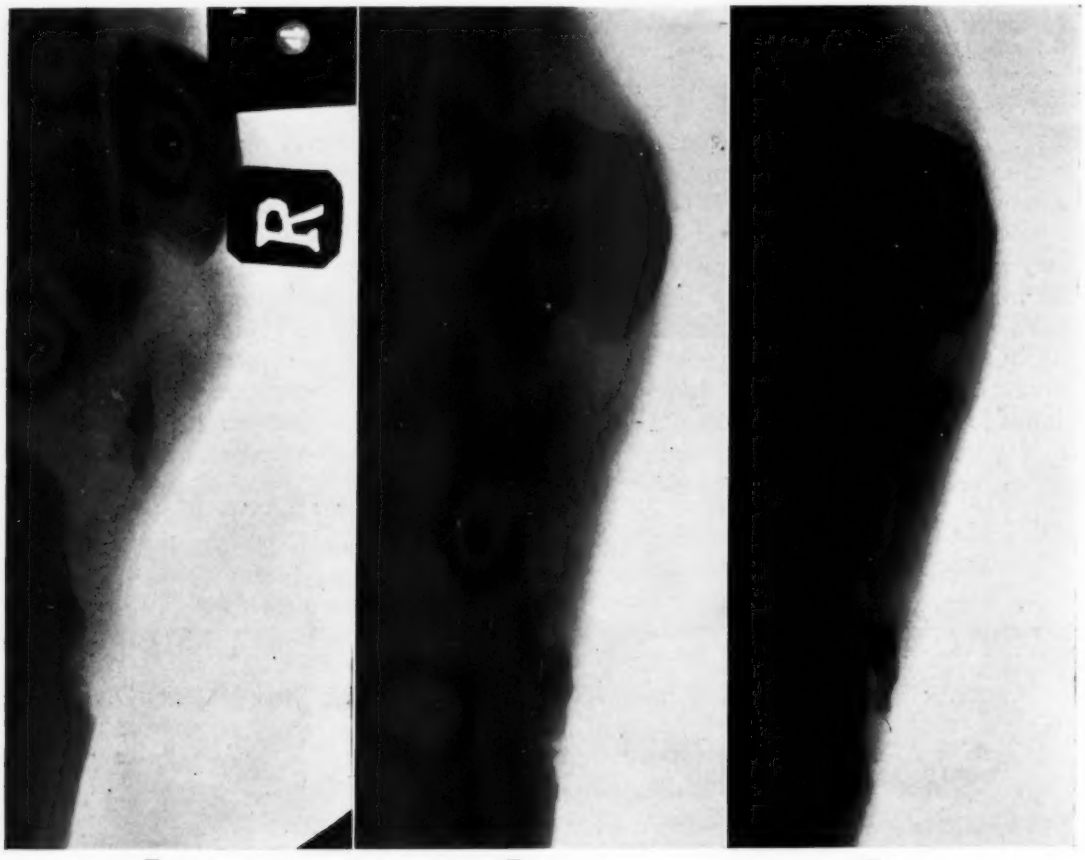

Fig. 1. Fig. 2. Fig. 3.

Fig. 1. Dec. 24, 1928. An irregular ¼ by 1 in. piece of bone has been pulled off the anterior tubercle of the upper end of the tibia. This is separated about 2½ in.

Fig. 2. Dec. 14, 1929. Old fracture of tubercle of tibia, which is in good position. Bony union appears to be present between fragment and shaft.

Fig. 3. Jan. 18, 1929. Small piece of bone, which appeared to be attached to tubercle of tibia, now appears to be loose and ununited.

Treatment: If there is not too much retraction of the patellar ligament, as shown by *x*-ray examination, and if the tubercle can be palpated and replaced, strapping and immobilization may effect a complete cure. If, however, retraction is great and swelling considerable, as in the case reported later, it is the writer's opinion that operative measures are then justified.

Prognosis: Good results have been reported by both methods after three

months. Untreated cases suffer much lameness.

This case is presented, first, because of the rarity with which these cases are seen; second, because of the age of the patient and the excellent recovery he made (it seems that this is the oldest patient on record to sustain such an accident); and, third, because of the changes which occurred in the avulsed tubercle which in no wise affected the functional result.

Fig. 4.

Fig. 5.

Fig. 4. Feb. 18, 1929. Tibial tubercle is not united, and appears to be absorbing. Calcified material is seen in infrapatellar region, and in soft parts along posterior part of lower end of femur; the latter is probably calcification in the vessels.

Fig. 5. June 22, 1929. Numerous loose pieces of bone or calcareous material seen in infrapatellar region, indicating non-union.

CASE HISTORY

I. S., aged seventy, attorney, married, wife and three adult children alive and well. No previous history of bone disease. This patient has always been in good health and is still active in his work.

Present Illness: About 11 P.M., on the evening of December 21, 1928, the patient, while stepping from the sidewalk to the street, lost his balance, tried to regain his poise, but fell into the gutter. He was dazed for a few moments, but rapidly recovered and was able to call a passer-by for help. He was carried to his hotel across the street and put to bed. This accident having occurred in a city over a hundred miles away, it was impossible to see the patient before the following day. Owing to his desire to return to his home, a cast was applied from the toes to the groin and the patient was transported to Hamot Hospital, Erie, Pa.

General physical examination showed nothing of interest aside from the local condition complained of except bilateral, indirect, incomplete, inguinal herniae which were held in place by a truss. The patient has worn this

device for many years with comfort and freedom from symptoms.

Local Condition. The patient complained of pain in his right leg upon the slightest motion. Function was lost. Measurement of the lower extremity from anterior superior spine to the internal malleolus showed no shortening. There was neither outward nor inward rotation of the thigh or leg. The knee was swollen very considerably but showed no discoloration. There was exquisite tenderness over the entire knee and further examination was so painful that it had to be abandoned. The patella could be palpated and appeared to be intact. The swelling was so great that it was assumed that there was a considerable effusion into the joint. Again, owing to the swelling and pain, it was impossible to determine further injury to the patella or its attachments.

X-ray examination revealed an avulsion of the tibial tubercle with some retraction of the patellar ligament and an upward displacement of the patella.

Operation. On December 24, 1928, the patient was given morphine sulphate grain $\frac{1}{6}$ by hypodermic and barbital grain 5, the leg having been prepared for operation. Under local anesthesia, using procaine 1 per cent, a field block infiltration of the knee was made after the method of Braun. Through an incision about 6 in. long, extending from just above the patella to a point just below the tibial tubercle, the site of fracture was exposed and found to be occupied by a large hematoma which was removed. The ligamentum patellae with its attached bony fragment was isolated and the tibial tubercle was united by No. 2 chromic interrupted sutures to the periosteum of the tibia. Several sutures of the same material were placed through the patellar ligament into the periosteum of the tibia. A full-length cast was applied with the leg in extension and the patient was returned to bed.

Postoperative Course. The patient remained in the hospital for seventy-two days during which time his temperature, pulse and respiration remained normal. All clinical laboratory data were negative. The wound healed by primary union. Twenty-eight days after operation (January 21, 1929) the upper half of the cast was removed and radiant heat was applied daily to the entire leg. The extensors of the thigh and leg were given light massage and a limited amount of active and passive motion. Two weeks later (February 5, 1929) the remaining half of the cast was removed and a posterior Cabot wire splint was substituted. The patient then began to walk on crutches. Two weeks later (February 19, 1929) the splint was removed and the patient was able to walk with crutches having good extension and flexion without pain. He was discharged from the hospital on March 4, 1929. By April 1 he was able to walk without lameness and without assistance from either cane or crutch.

The roentgenogram showing the original injury is self-explanatory. The film exposed on January 14, 1929 is interesting in that the roentgenologist reported an old fracture of the tubercle of the tibia which was in good position and that the bony union appeared to be present between the fragments and the shaft. A month later, however, this fragment appeared to be loose and ununited. On March 18, 1929, or two weeks following his discharge from the hospital, the roentgenologist reported that the tubercle of the tibia was not united and appeared to be undergoing absorption. The last film made on June 22, 1929 showed practically no further change except possibly some additional absorption of the fragments, but, as in the preceding roentgenograms, the patellar ligament appeared to be united by fibrous union to the site of the fracture.

At the time this report is being written one year and five months following the injury, the patient has resumed his occupation and is able to walk about with no lameness and with no assistance. Flexion and extension of the leg on the thigh and of the thigh upon the abdomen are not limited in any degree.

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INFECTED PELVIC HEMATOCELE CONTAINING FETAL BONY ELEMENTS*

HARVEY B. MATTHEWS, M.D.

BROOKLYN, N. Y.

MRS. A. H., No. 2499, was admitted to the Gynecological Service at the Long Island College Hospital with the chief complaint of general debility, pain across the lower abdomen, and lumbosacral backache. She has been married ten years, was twenty-four years of age, Hungarian by birth and had three children, the youngest six years and the oldest eight years. She has had no miscarriages.

FIG. 1. Fetal bones removed from pelvic abscess and assembled to resemble true fetal skeleton. History of case and stage of development of bones are about that of a four to four and one-half months' fetus.

Past and Family History: She began to menstruate at the age of twelve years, regularly every twenty-eight days, five days' duration, using 4 to 6 napkins a day, no pain, no clots. After marriage there was no change in the menstrual history until one year before onset of present illness when periods became irregular, coming on every two to three weeks and flowing from two to three days to as long as eighteen to twenty-one days and without pain. Last regular period was six months previous, followed by spotting for one month. The patient was curretted by her family physician for the relief of this spotting. Following the currettage there was no bleeding for two weeks. Then the patient began to bleed again and had a moderate amount of bloody discharge for seventeen days, during which time she had more or less fever. She was at this time sent to a hospital.

Excerpts from the record of the hospital to which she was admitted were as follows: Admission diagnosis was postabortal sepsis and pelvic cellulitis; temperature 101.6°F., pulse 120, respiration 24. Blood examination: White blood cells 27,800; polymorphonuclear cells 87 per cent. Temperature ranged from 99° to 102.2°F. for six days and then remained normal until discharge 12 days later. Pelvic examination at this time revealed a uterus the size of 4½ months' pregnancy, limited in mobility, no tenderness, moderate pelvic exudate.

Two weeks after discharge from the hospital the patient began to bleed again and continued to spot at irregular intervals for the next three weeks. Following this period there was no bleeding for eight weeks and then there appeared what the patient thought was a menstrual period in which she flowed about normal for two days, this being five months since the beginning of the present trouble. The pain in the right side and lumbar region had progressively grown more severe until at present these symptoms were quite disabling.

At this time, three and one-half months after her discharge from the former hospital, the patient was admitted to the Gynecological service of the Long Island College Hospital, complaining of general debility, severe lower abdominal pain and lumbosacral backache. She had lost considerable weight since the onset of her illness six months ago. Admission temperature was 99.6°F., pulse 120, respira-

* Submitted for publication September 30, 1930.

tions 25. Blood count: Red cells 3,600,000, white blood cells 13,000, polymorphonuclear 75 per cent, small lymphocytes 17 per cent, large lymphocytes 10 per cent, hemoglobin 66 per cent, and blood pressure 122/70. Physical examination revealed a well developed, fairly well nourished, anemic, white female, who did not appear acutely ill. Head and neck negative and teeth in good condition. Tongue coated but moist. Lungs negative. Pulse 120, good quality. Abdomen slightly distended and moderately tender throughout. There was a mass reaching four fingers breadth above the pubis and extending across the lower abdomen, especially toward the right side which was hard in consistency, quite tender and not movable. Extremities negative. Pelvic examination disclosed a relaxed, lacerated pelvic floor, unilateral lacerations of the cervix, with moderate chronic endocervicitis. Cervix and uterus pushed forward and upward by a large fluctuating moderately tender mass filling the cul-de-sac and extending upward in the midline to four fingers above the symphysis pubis and up the right lateral wall of the pelvis almost to the level of the anterior superior spine. Diagnosis: Pelvic abscess following postabortal sepsis. Recommendation: Posterior colpotomy and drainage.

Operation: When the cul-de-sac of Douglas was opened, a large quantity of foul pus escaped, following which bony elements appeared. These were fished out and have been arranged to form almost a perfect fetal skeleton as may be seen in the illustration (Fig. 1). Drainage was established and the patient returned to her bed in good condition.

Convalescence was excellent. The highest temperature was 100.2°F., pulse 90 to 100 the first week, coming down to 80 during the second week. The patient was discharged on the twenty-first day after operation. Discharge examination: Relaxed pelvic floor, cervix points in axis of vagina and there is a slight right unilateral laceration and moderate chronic endocervicitis. Uterus anteflexed and retroposited and is more or less fixed by a small non-sensitive exudate in the posterior and right lateral cul-de-sac of Douglas. There is considerable granulation tissue along the line of the healed posterior colpotomy incision. The general condition was satisfactory in every respect.

COMMENTS

The most interesting points in the study of this rather unusual case is the question of whether the uterus was punctured at the time of the currettage by her family physician (six months previously) through which the fetus (four to four and one-half months) was extruded into the cul-de-sac of Douglas. Here it became encysted and infected. Or was it an ectopic gestation that had developed four to four and one-half months before rupture or abortion took place? In the light of the history and operative findings we believe that it was an extra-uterine pregnancy which ruptured or aborted, without excessive bleeding, gravitated into the cul-de-sac of Douglas, became encysted and infected and later formed a pelvic abscess.

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EDITORIALS

THE AMERICAN JOURNAL OF SURGERY'S CONTRIBUTION TO RADIOLOGY IN 1930

IN retrospect the Editors and publisher feel considerable satisfaction in the part played by our publication in recording the radiologic advances of the year just closing. Nearly every year marks some important advance in the rapidly extending field of radiology; 1930 has been no exception, for it has witnessed the introduction of successful intravenous urography by Swick, von Lichtenberg and their co-workers, first published in English in these pages.

Another important step forward is the contribution of Saito and his colleagues on successful and useful blood-vessel visualization in the living, which in conjunction with the achievements of dos Santos in aortography opens the way for practical clinical blood-vessel visualization in the diagnosis of injuries to blood vessels and in brain tumors while making renal tuberculosis discoverable at a still earlier stage.

In the field of gastroenterology 22 articles have appeared covering the entire alimentary tract and the gall bladder. In addition to the discussion of important fundamentals in gastrointestinal and gallbladder radiology, special lesions have been studied, such as benign tumors of the stomach and intestine, gastric sarcoma, gastrocolic fistula, hernia into the lesser peritoneal cavity, differential diagnosis between peptic ulcer and chronic appendicitis, the detection of small intestinal adhesions, and a scholarly essay on the question of the chronic appendix (Maes).

Honk's article on the simulation of chronic appendicitis by other pathological conditions is especially valuable.

The lungs and upper respiratory tract have been considered in 12 papers, including discussions of the nasal sinuses, antral polypi, an ingenious device for lipiodol visualization of the bronchi, and a valuable assortment of beautifully illustrated papers on empyema, pleurisy, pulmonary abscess, mediastinal and subphrenic lesions, hernia of the diaphragm, and an important paper on apical chest tumors. Professor Belot of Paris contributes an excellent and timely paper on better protection in upright fluoroscopy.

In the genitourinary diagnostic field, in addition to the papers on intravenous urography by Swick and by Lubash, 19 papers cover uterosalpingography, urinary calculi, anomalies and operative damage to the ureters, renal cysts and tumors, foreign bodies in the urethra, diverticula of the bladder, and a new urographic medium. A valuable special article considers suppurative myositis of the iliopsoas muscle as stimulating renal pathology.

Bone and joint radiology is represented by 25 diagnostic articles besides several on radiation therapy. Papers on fractures and dislocations cover the entire spine, pelvis and extremities, and there are discussions of pathological fractures in primary bone tumors of the extremities, tumors of the thoracic cage, tumor of the pubis, congenital bone lesions, fluoroscopic control of fracture surgery, and several articles on spondylitis. Moodie's studies in paleopathology contain much material of value to the radiologist. Of no small importance is the masterly discussion by Illievitz on fractures in relation to disability.

Twenty-five other articles discuss a variety of subjects: radiological aspects of some neuromata; radiotherapy of syringomyelia, bone tumors, malignant granulomata, alimentary tract carcinoma, benign and malignant genitourinary tract disease; foreign bodies in the brain and elsewhere and methods of removal; a complete treatise on obstetrical measurements and the localization of pulmonary lesions; a valuable paper on the embryological development of bone. Four contributions on roentgenology in hospitals and medical schools have special reference to the teaching of this subject. Diocles' dissertation on telestereoroentgenography tells all there is to be known about the principles of stereography and their application to *x*-ray diagnosis.

Thus, in a journal devoted to surgery and its allied sciences, there have been published more than 100 communications of direct interest both to the surgeons and radiologists. As has been emphasized several times in these pages, the radiologist should preserve his usefulness as a clinician by participating broadly in the study of surgical lesions, and should seek to keep abreast of the progress of surgery in order to render the fullest measure of service in his diagnostic and therapeutic work.

James T. Case.

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P. W. Stickey

[1865-1930]

The American Journal of Surgery
N. S. Vol. x, December, 1930

PRESTON M. HICKEY 1865–1930

IT is with a profound sense of irreparable loss that we record the passing of one of America's ablest radiologists in the death of Preston Mannaseh Hickey, Professor of Roentgenology at the Medical School of the University of Michigan.

The sterling honesty, friendliness, loyalty and patience of his gentle nature endeared him to all who came within the sphere of his beneficent influence, so that he was widely loved and respected, most of all by those who had the good fortune to be numbered among his students. He will be greatly missed by the various radiological organizations to which he contributed so much as well as by the numerous other medical bodies of which he was a valued member.

Dr. Hickey received his A.B. degree from the University of Michigan in 1888 and in 1892 his medical degree from the Detroit College of Medicine with which institution he maintained active teaching connection until his removal to Ann Arbor in 1922. At first a teacher of pathology, he gradually worked into clinical medicine as a laryngologist, which he continued to practice until after the War after which he devoted himself entirely to radiology. His radiological experience, however, began shortly after the publication of Roentgen's discovery, with such success that by 1899 he was already doing fracture radiology. His interest, begun thus early, continued with increasing results all the rest of his life, his contributions covering especially the nasal accessory sinuses, the mastoids, and the lungs. As a laryngologist, he was able to make pioneer contributions to the localization and bronchoscopic extraction of swallowed and inhaled foreign bodies.

In a literary way Dr. Hickey's outstanding contribution to radiology was the founding of the American Quarterly of Roentgenology, later known as the American Journal of Roentgenology, which he edited for many years.

One of the first to respond to the call to arms in 1917, Dr. Hickey assisted in the organization of Base Hospital #17, the Harper Hospital Unit from Detroit, going overseas with this group in July of 1917. The writer, as Director of Roentgenology for the American Expeditionary Forces, recognized immediately how much more helpful Dr. Hickey could be at general headquarters than in a hospital unit, and, with the reluctant consent of Col. McLean and his associates of Base Hospital #17, Major Hickey was transferred to assist in the organization and direction of the *x*-ray service of the A. E. F. Once more the writer is proud to acknowledge the valuable help and the delightful comradeship so freely given him by Doctor Hickey during 1917 and 1918 in France.

So, in this hour of separation from a beloved colleague, we are glad of this opportunity to pay a formal tribute to Preston M. Hickey, scientific, accurate, patriotic, progressive, painstaking and untiring, broad, kindly, sympathetic, and always intensely human.

James T. Case.

"TRENDELENBURG POSITION"

HOW often does the surgeon order a patient in the "Trendelenburg position"? In shock and other conditions it is still a routine part of the treatment.

Friedrich Trendelenburg lived and worked in the time of the present generation of physicians. He was born on May 24, 1844 in Berlin. His early education was at the feet of his mother and father. His mother taught him English, his father, Latin and arithmetic, while an aunt drilled the youth in grammar. Eventually he attended a boys' school in Berlin. Later, he was given the choice of going to a boarding school in Berlin or to Scotland with his family for a year. He went to Scotland and while there studied anatomy, embryology and physics. In 1864 he took his preliminary medical examinations and in 1866 was given his medical degree.

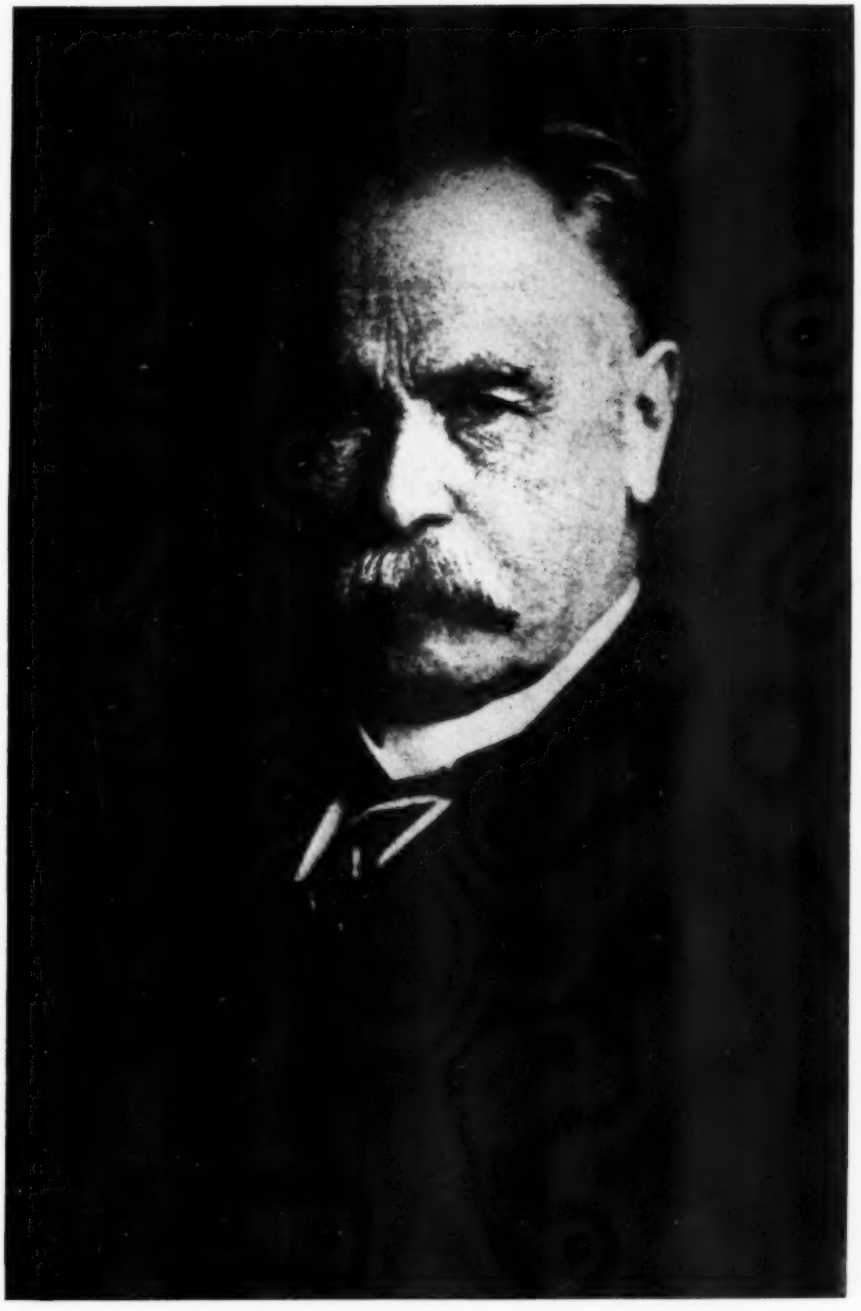
His positions were many. He was a military surgeon. He wrote a thesis on Ancient Indian Surgery. He was appointed an assistant to Langenbeck. He founded the German Society of Surgeons. In 1874, he was made a director of the surgical ward at the Friedrichschain Hospital in Berlin. In order, he became Ordinarius in Surgery at the Universities of Ristock, Bonn and Leipzig. He was at one time Chairman of the German Society of Surgeons and, at the time of his death, its historian.

Trendelenburg wrote many important papers. He did exceptionally splendid work in the field of plastic surgery, congenital hip-joint diseases, pulmonary embolism, and in the physiology of varicose veins. His work in the restricted limits of gynecology and abdominal surgery was such that his name is listed among the surgical immortals.

It is interesting to note that Willy Meyer of New York was the first to record the Trendelenburg position. Meyer was at the time a student of Trendelenburg and published the description with the permission of his "venerable chief." Two weeks ago the writer sat across a luncheon table from Doctor Meyer, who forty-five years ago was a student under Trendelenburg. What a privilege! One day we must get Doctor Meyer to write of his student days in Germany.

Originally the position was tried as a means of introducting air into the open bladder following the "principle of Sims' posture where the vulva is the most elevated point of the body and the opened vagina admits air because of negative intrapelvic pressure and thus becomes distended."

On December 15, 1924 in his eighty-first year, Trendelenburg died. T. S. W.



F. Trendelenburg.

[1844-1924]

The American Journal of Surgery
N. S. Vol. x, December, 1930

[From Fernelius' Universa Medicina, Geneva, 1679.]

BOOKSHELF BROWSING

STUDIES IN PALEOPATHOLOGY, XXVIII

THE PHENOMENON OF SACRALIZATION IN THE PLEISTOCENE SABRE-TOOTH

ROY L. MOODIE, PH.D.

SANTA MONICA, CALIF.

THE anomalous phenomenon of the exaggerated development of the transverse processes of the last lumbar vertebra until they look like parts of the sacrum is known in medical literature as sacralization. That this may be accompanied by co-ossification with the sacrum is obvious. The relation of this condition, often seen in roentgenological examinations of the lumbosacral region, to

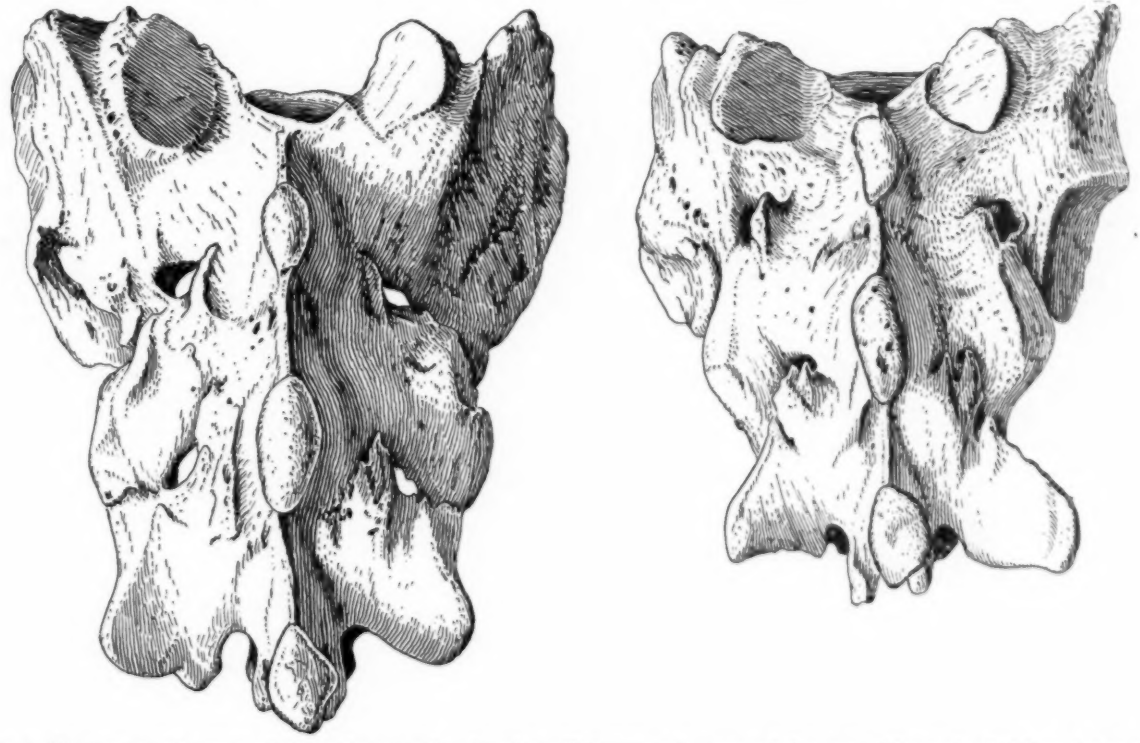


FIG. 1. Two normal sacra of the sabre-tooth, showing differences in two adults, possibly male (left) and female (right). The left sacrum has a length of 150 mm.; the right measures 122 mm. The dorsal view shows the complete union of the three vertebral units to form the sacrum. This union takes place relatively early in life.

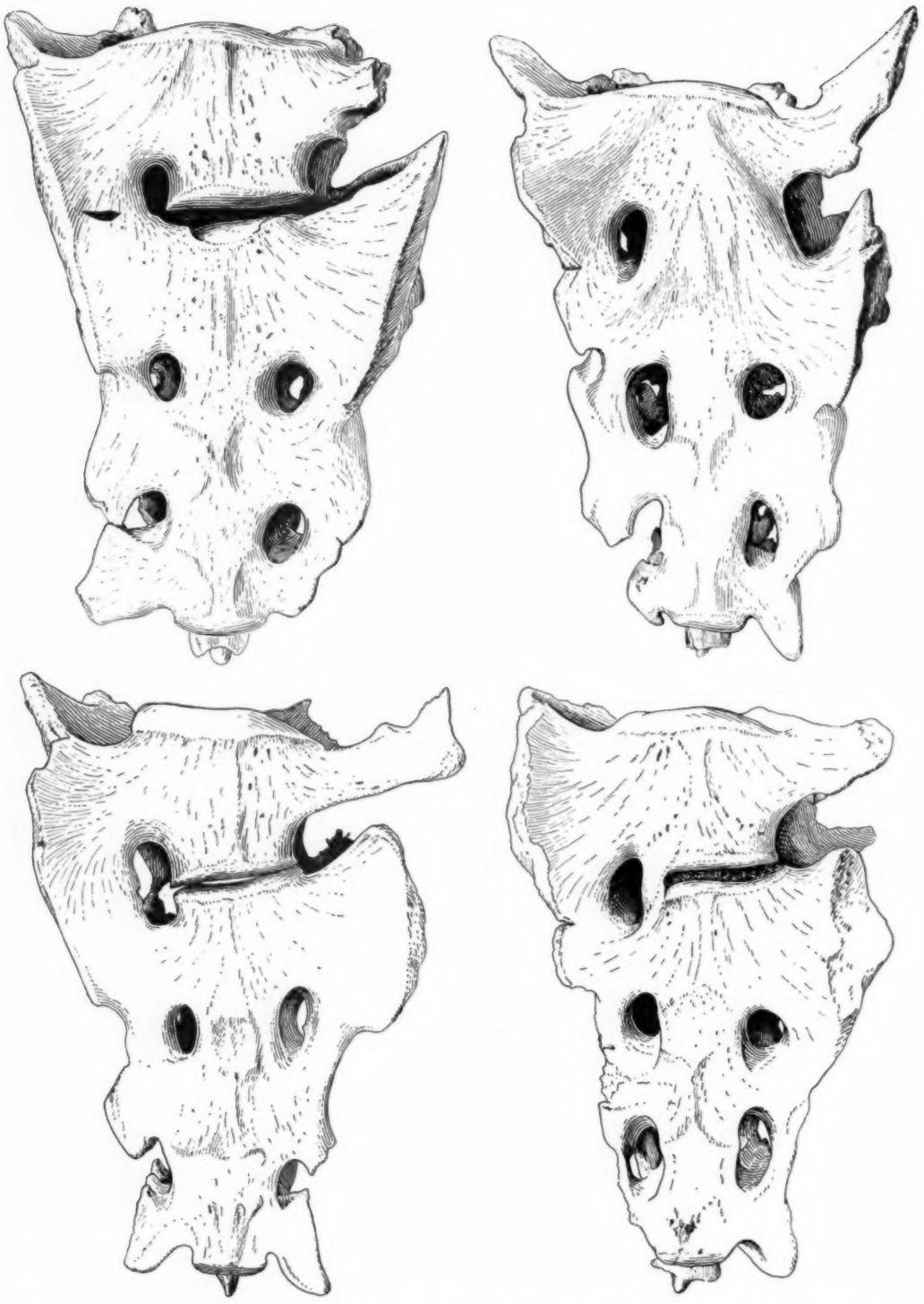


FIG. 2. Four examples of sacralization in the sabre-tooth, Pleistocene, of the Rancho la Brea. All co-ossifications are on the right side of the sacrum. The measurements of these anomalies are: full length, *upper left*, 180 mm.; *lower left*, 165 mm.; *upper right*, 166 mm.; *lower right*, 157 mm. All the anomalous sacra show a right lateral curvature, some more pronounced than others. (Specimens in the Los Angeles Museum.)

lumbosacral pain has attracted some attention among medical men. The anomaly creates disturbances in the lumbosacral passages of nerves and blood vessels, which may cause pain.

The phenomenon has never been described in vertebrates other than man, so far as the writer knows, and the presence of five undoubted examples of this condition among the 1034 young and adult sacra of the sabre-tooth (*Smilodon californicus*) of the Rancho la Brea preserved in the Los Angeles Museum, Exposition Park, has led to this brief description of the phenomenon.

The five examples all show co-ossification on the right resulting in an asymmetry, with a lateral curvature to the right. Three of them were secured from Pit 3; one from Pit 60 and one from Pit 61. They are all apparently adult.

The sacrum shown in Figure 2, *upper left*, presents a reduction in size of the upper foramen, and a curvature to the right brought about by the intense co-ossification of the transverse processes. The articular surfaces on the right side have a length of 10 cm., and a width of 6 cm., including the surfaces of the co-ossified lumbar vertebrae; while the left articular surface offers dimensions of 7.5 cm. by 5.5 cm. The posterior zygopophyses of the lumbar vertebrae are not co-ossified with the sacrum, although the three normal sacral components are fused into a single mass.

The sacrum shown in Figure 2, *lower left*, is unusually slender, with a firm co-ossification of the right transverse processes, resulting in a marked asymmetry, with a curvature to the right. The length of the right sacroiliac articular surfaces is 9 cm. with a width of 4.5 cm. The normal sacral elements are thoroughly co-ossified. The posterior lumbar zygopophyses are free. The left sacroiliac articulation measures 5 cm. by 5.5 cm.

Spondylitis deformans enters as a factor in the interpretation of the sacrum shown in Figure 2, *upper right*. This is due to the ossification of the entire mass of the ventral longitudinal ligament, which obliterates all trace of the intervertebral surfaces. The right sacroiliac articulation is very rough, measuring 9 cm. by 6.5 cm., while the left surface measures 5.5 cm. by 6 cm. The left transverse process of the lumbar vertebra is greatly roughened by disease. The sacral elements are united.

Still another condition is shown in the sacrum seen in Figure 2, *lower right*, in the ossification of a part of a longitudinal ligament, extending up quite a distance on the lumbar vertebra. The right articular surface measures 9 cm. by 5 cm. The left is pit-worn. Superiorly all traces of separate structures are obliterated.

The fifth example of sacralization shows co-ossification of transverse processes on the right, resulting in a slight asymmetry, with no traces of spondylitis deformans. The right sacroiliac junction measures 9 cm. by 4 cm., while the left shows almost equal measurements.

The phenomenon of sacralization in itself is not pathological, but an anomaly due to disturbance in growth, doubtless during early embryonic life. It is associated with diseased conditions without any definite relation to them.

BOOK REVIEWS

CLIO MEDICA. A Series of Primers on the History of Medicine. Ed. by E. B. Krumbhaar, M.D., N. Y., Paul B. Hoeber, Inc., 1930. Vol. I. THE BEGINNINGS: EGYPT AND ASSYRIA, by Warren R. Dawson, F.R.S.E. Vol. II. MEDICINE IN THE BRITISH ISLES, by Sir D'Arcy Power, K.B.E. Vol. III. ANATOMY, by George W. Corner, M.D. Vol. IV. INTERNAL MEDICINE, by Sir Humphry Rolleston, Bart.

Probably at no time as at present has so much genuine interest been shown in the history of medicine. Physicians are curious to learn of their heritage. And although books and tracts without number have been published on the history of this branch of science only a minority of the profession have been sufficiently interested to add them to their libraries. Perhaps the fault may be divided between the authors and the publishers. However, in Clio Medica there is no excuse for all physicians not possessing these "primers" and mentally digesting the contents. In the first place, they are made to fit anyone's pocket. They may be read in two or three sittings. They are written by authorities in the various branches of medical historical lore. And they are written in a style that makes pleasant reading. Last, but not least, they are inexpensive. It is planned by the publishers to cover the entire field of medical history and before the series is finished the volumes will make an impressive array.

To date, Dr. Krumbhaar has done an excellent bit of editorial work. He has shown discrimination in choosing his authors. He has been fortunate in having men of such proven reputation do this work.

From the editor's preface we quote: "Since the times of Aldines and Elzevirs, small easily portable booklets have been popular with the intelligent reader. Today books that add no appreciable burden to the coat pocket are real helps to the busy worker or student in gaining ready access to considerable worthwhile reading . . . Conveniently small and inexpensive, yet prepared by recognized authorities in their chosen field, each volume will aim to present the story of some individualized phase of the history of medicine in such compact, connected, convincing and reasonably complete form that the medical undergraduate, the specialist, the busy practitioner and the "intelligent layman" will be attracted to a few hours' reading, which in many cases will doubtless prove the introduction of an awakened interest to a more comprehensive study . . . "

To date we have before us, and have read and reread with true pleasure, The Beginnings: Egypt and Assyria by Warren R. Dawson, Medicine in the British Isles by Sir D'Arcy Power, Anatomy by George W. Corner, and Internal Medicine by Sir Humphry Rolleston. To follow shortly are: Physiology by John Fulton, and Pathology by A. S. Warthin.

All in all delightful. Whether or not a student of the history of medicine, if only for the sheer joy one will derive in the reading these little volumes may well be in every physician's possession.

THE STORY OF A SURGEON. By Sir John Bland-Sutton, Bt., F.R.C.S. With a Preamble by Rudyard Kipling. Illus. Boston, Houghton, Mifflin Co., 1930.

Few books are adorned by so choice a foreword as the "Preamble" with which Rudyard Kipling has graced this record of the life of his distinguished friend. Delightfully written in quaint odd English it bestows the title of "The Story of a Hospital" on the autobiography of a man much of whose life was given to the service of the Middlesex Hospital, with which institution his name will always be associated.

Bland-Sutton has been for so many years one of the best known surgeons and teachers of surgery in London that some of his many admirers in the United States will be amazed to learn of his many activities in other fields. As an anatomist, and especially as a comparative anatomist, his achievements have been somewhat overshadowed by his renown as a surgeon. Like his great prototype, John Hunter, he developed at an early age a veritable passion for the study of the anatomy of all living animals, and also their pathology. His many hours passed in the dissecting room at the London Zoo were far from wasted. Even his great work on "Tumors" probably owes much to these researches. In the course of his long life he has had not only many curious and interesting experiences but he has sought them out, and his brief recitals of his various travels in Africa, Egypt and Russia show how much a keen observer can glean from such journeyings.

Not the least interesting portions of the book are his anecdotes of the many distinguished persons with whom he has worked or been brought in contact. Entering the profession before the principles of antisepsis and asepsis had been established he has lived to see their triumph. He was active in the early days of gynecology, the days of Lawson Tait and Spencer Wells, and he was one of the chief factors in establishing that branch of surgery on a scientific basis. His reminiscences of Pasteur, Lister, Sir Frederick Treves, and other of the great men who were his older contemporaries are historic mementoes of great value.

The book is full of little asides on various subjects in natural history which are charming as the somewhat similar sketches of Frank Buckland or Gosse.

Lastly this is a modest autobiography. The many honors which have been conferred upon its Author are referred to in only the most casual manner, if at all. This book will be a solace to the older members of the profession and a stimulus to the younger.

Francis R. Packard.

Emergency Surgery. By Hamilton Bailey, f.r.c.s. (Eng.) N. Y., William Wood and Co., 1930.

This is the first volume of a two volume work. It covers the abdomen and pelvis. We found it a valuable book. In the introduction the author considers sterilization, towels, abdominal pads, etc. Beginning in Chapter 2 he considers Laparotomy and in subsequent chapters deals with Peritonitis, Acute Appendicitis, Some Conditions Simulating Appendicitis, The Stomach, The Gall-Bladder and Bile Ducts, Other Emergency Conditions of the Upper Abdomen, Intra-Abdominal Injuries, Intestinal Obstruction, Intestional Obstruction in the Newborn, Acute Intussuseption, Strangulated External Hernia, The Femals Generative Organs, The Rectum and Anus, Some Post-Operative Complications, The Kidney, The Bladder and Prostate, and The Urethra, Penis, and Testicle.

The illustrations are very good. Personally we got a great deal out of reading this book and are looking forward with interest to the second volume. It is a work every surgeon should have in his library.

Historic Artificial Limbs. By Vittorio Putti, m.d. N. Y., Paul B. Hoeber, Inc., 1930.

This very delightful essay, first published under the Bookshelf Browsing section of The American Journal of Surgery, is now issued in book form. The author offers the various phases of inventive advancement and those responsible for the progress made in the construction of artificial limbs. The book itself is a beautiful thing, the illustrations are well done, the author's style is engaging. To the orthopedic surgeon and anyone interested in the medical past and present this work will prove worthwhile.

The Theory and Practice of Radiology, With a Synopsis of Radiology and Radiotherapy. A Treatise in four volumes. By Bernard J. Leggett, St. Louis, Mosby, 1930.

The author has undertaken a monumental work, and if the last volume, which has not yet appeared, comes out as satisfactorily as the three before, the work will be truly a monument not only to his industry but to his vision in foreseeing the need of such a publication.

Volume I. Volume One concerns "Electrical Theory Applied to Radiology." The volume is complete in 240 pages with an adequate index. At the end of each chapter is given a list of questions or exercises which are based upon analagous questions set in the examination at Cambridge for the Diploma of Radiology and Medical Electrology. The comprehensive knowledge of the theory and practice of radiology contemplated by these questions very highly recommend the courses leading up to this diploma. Volume One includes a discussion of mechanical units, the electric circuit, the magnetic current, varying currents, electromagnetic machinery, and the electron theory.

Volume II. Volume Two, entitled "The Physics and Measurement of X-Radiation," is slightly more voluminous than Volume One. There are over 300 pages on light and heat, the origin of *x*-radiation, *x*-radiation spectroscopy, properties of *x*-radiation (absorption, fluorescence, scattering, compression, refraction, luminescence, photo-chemical and photo-electric effects, polarisation), the measurement of quality of radiation, the measurement of intensity, the dangers of radiology and how to protect one from them. As in the preceding volume, each chapter is followed by a series of

exercises and questions based upon analagous questions set in the Cambridge examination for a Diploma of Medical Radiology and Electrology. The appendix to this volume contains a summary of the recommendations upon protection against *x*-ray and radium injuries, as they exist in England, Russia, Sweden, Germany and the United States of America. The French report is not included for the reason that at the time of the publication of this book this report was not available.

Volume III. Volume Three, of 550 pages, is devoted to "X-Ray Apparatus and Technology." From a practical diagnostic standpoint one doubts somewhat the advisability of printing such a volume of literature on apparatus, much of which is out of date; but from the pedagogic standpoint this information should be available in print. It is therefore included in this work in a very comprehensive manner. The author has apparently made the effort to bring into this book a complete description of the construction and management of all the different types of instruments made by all firms and in all countries. The localization of foreign bodies is discussed at length. There is a chapter on the radiological building which should be especially interesting to radiologists and hospital attendants who are interested in the construction of new housing for *x*-ray apparatus. Many technical details concerning the construction of protection apparatus in *x*-ray rooms are included in this chapter.

From the standpoint of the diagnostician we await with great interest the appearance of the fourth volume on "Diagnostic and Therapeutic Radiology." Twelve chapters are proposed, nine on diagnostic radiology and three on therapeutic radiology. If the last volume is done with the same comparative standard of completeness and thoroughness as characterizes the three preceding volumes, it will be a ponderous tome but so rich in information that every radiologist should feel obliged to possess it.

James T. Case.

Laboratory Medicine. By Daniel Nicholson, M.D. Cloth, 437 pp. 109 illus. Phila., Lea & Febiger, 1930.

This volume presents a concise outline of the different procedures in clinical pathology useful to the practitioner of medicine with supplementary information on the normal ranges in various tests and other useful data.

It is a question however if a textbook for students such as this is, should depart from generally accepted views to voice personal opinion as it does in numerous places. For example the following are noted: "Never ask for both blood urea and non-protein nitrogen; they have the same significance." "Order uric acid only in cases of gout or suspected gout." "Ask for blood calcium determinations only in tetany of unknown origin." These instructions disregard not uncommon and often valuable other uses.

The following statement is found on page 65: "If there is a total leucocyte count over 25,000 with little or no fever and an enlarged spleen, a diagnosis of myeloid leukemia should be made." This is definitely misleading and contrary to established practice that no clinical diagnosis of myeloid leukemia is justified without a characteristic blood picture throughout. On the same page there is the following: "Bacillary infections do not produce an increase of the polymorphonuclear cells etc." It is only necessary to mention diphtheria.

On page 83, on the subject of blood grouping, it is stated that Moss 2 is the same as Jansky 2 and that Moss 3 is also the same as Jansky 2. This is evidently a misprint. The confusion apt to arise from the use of these various classifications is a serious matter at best, and particular care is imperative in the absolutely accurate preparation of chapters in books which deal with this subject.

Frederic E. Sondern.

A Text-Book of Gynecology. By Arthur Hale Curtis, M.D. Phila., W. B. Saunders Co., 1930.

In the inner conclaves of gynecologists it is admitted that Dr. Curtis has attained position among the first three ranking gynecologists in America. In recent years he has taken unto himself no little fame as a teacher of unusual parts and ability. With this reputation and background it is not amiss to say his book was awaited with interest. We have heard it criticized by lesser lights; but, upon reflection, their criticisms were devoted to minor points: too many illustrations for a certain operation; why does he start right off with Infectious Processes, etc. None we have heard is worth serious consideration. To us, it was delightful to open such a book and see missing the usual opening chapters on anatomy and physiology that one can, if he desires, get out of books

devoted to these subjects. Curtis has written a book that will appeal not only to gynecologists but, also, to the majority of the profession. He writes well. The reading makes one discern the invisible hand of the finished, seasoned teacher. There are 222 illustrations, chiefly by Tom Jones. All unnecessary material has been omitted and so the work is only 380 pages long. It is truly a work of merit.

Practical Treatise on Diseases of the Digestive System. By L. Winfield Kohn, M.D. Phila., F. A. Davis Co., 1930.

This treatise is done in two volumes covering 1125 pages of text. There are 542 engravings, including 7 full-page colored plates. The work is in reality a textbook. The author says that in the compilation of the work the needs of the student have been constantly in mind. Physicians engaged in practice find it difficult properly to diagnose and treat diseases involving the alimentary tract, without recourse to a thoroughly modern, practical reference book on this special subject. With this in mind the author has attempted, and successfully, to supplement their present knowledge of gastroenterology in his volumes.

Intestinal Toxemia, Biologically Considered. By Anthony Bassler, M.D. Phila., F. A. Davis Co., 1930.

Reading the author's long Preface we came to: ". . . because I had decreed that the final report of the work had to cover a large number of cases in which constant research and laboratory detail had to be engaged in—work, which at best is far from easy and plain—I concluded not to write this experience in more detail until five thousand cases had been treated. This has taken thirty years of time, constant researching, examinations, checking and rechecking, and the estimation of results immediately accomplished, but, more particularly, results apparent years after termination of treatment." This gives an idea of the thoroughness with which the author has handled his subject.

Whether or not you agree with all the author says, what he writes will command serious attention. Naturally most gastroenterologists will read it, but we would that many men labelled "general practitioners" would spend some time each day and learn the basic fundamentals to be found between its covers. The book deserves a wide circulation.

Die Wirbelbrüche und Ihre Ergebnisse. By Dr. Walter Haumann, Stuttgart, Ferdinand Enke, 1930. Pp. 180, 20 illus.

The monograph here under review details the experience of the author in 204 fractures of the spine treated over a five year period from 1919 to 1925, in a hospital in the Ruhr coal mining district, together with 555 cases occurring during 1919 to 1920 in the insurance district of that region. As a statistical summary of so extensive a material the book is of great value.

The first section of the book takes up the pathology both from the clinical side and as seen at autopsy. The importance of the *x*-ray is stressed, and particularly the fact that in many cases only in the lateral *x*-ray exposure may the fracture be demonstrated, a fact that is still frequently overlooked in surgical practice.

The treatment as developed by Haumann, which was used in substantially all of the hospital series of 204 cases, is recumbency in bed, sometimes with a pillow under the fracture site, for six weeks. Energetic physiotherapeutic measures are employed almost from the first, including at first heat and massage, and later active mobilization exercises. At the end of that time the patient is gotten up without support, the average hospital stay being about nine weeks. Laminectomy is never done. Only twice was a fixation operation done. No attempt is made to reduce deformity.

Much of this, of course, would be considered rather inadequate treatment in America, where the practice in general has been to make some systematic attempt to restore the anatomical conformation, as in any other joint fracture, and then to protect the crushed vertebral body from overstrain until consolidation is complete. Fixation operations are here utilized to a far greater degree.

X-rays of 20 cases are reproduced in the text, illustrative of different types of injury. It is to the reviewer a matter of regret that substantially no *x*-rays of what might be called end-results are reproduced, despite the opportunity which was here offered for late observations. One other point which your reviewer, as an orthopedic surgeon, cannot refrain from comment upon is this: here and there in the book it is advanced as a criterion of spinal function that the patient can place his finger tips so and so many centimeters from the floor. A statement with regard to the degree of spinal

mobility would have been much more to the point, since, as is well known to every one, by far the greatest portion of trunk flexion is carried out at the hip joints.

The end-result study is based rather largely on percentage disability as determined from the insurance standpoint. It at once becomes evident to the American reader that the standards which maintained in the Ruhr during the post-war reconstruction years bear little relation to those of our compensation laws. A single case may be quoted to illustrate (p. 64). A fracture of the first lumbar vertebral body with initial symptoms of a complete cord lesion, but subsequently developing a marked spastic paraplegia. He was eventually able to get about with the aid of crutches. At the end of two years he was given a percentage disability rating of 40 per cent. Such a case, in American insurance practice, would be rated as substantially a 100 per cent disability. One is tempted somewhat to interpret the physical integrity of those cases in the series who eventually were able to return to their previous occupations by considerations such as the above.

Despite one's differences with the author's point of view, it should be stated that the book should prove of considerable value to all those interested in this very difficult question of the management of fractures of the spine.

Arthur Krida.

Practical Midwifery for Nurses. By Bethel Solomons, M.D. Oxford Univ. Press, 1930.

In the Preface the Author writes: "The long-standing success of Practical Obstetrics by Tweedy and Wrench has continued since the publication of the last edition in 1929, when I took charge of this well-known textbook. Having been asked by many nurses to produce a smaller work on the same lines, I decided to acceed to their wishes. While the requirements of modern obstetrics, and especially my own views, will be found in the book, some of the original ideas of Tweedy and Wrench still remain, and to these two authors my acknowledgments are especially due. An effort has been made to bring before the nurse not only hospital work, but also the subject as it applies to private practice."

This book is carefully done. The subject is thoroughly covered. Any nurse might well spend a few hours reading between its covers. We recommend it be added to the lists prepared by the supervising nurse of training schools throughout the country for the reading and the study of nurses in training.

Hieronymi Fracastorii. De Contagione et Contagiosis Morbis et Eorum Curatione, Libri iii. Transl. and Notes by Wilmer Cave Wright, ph.d. Pp. 411.

History of Medicine Series Issued under the Auspices of the Library of the New York Academy of Medicine. No. ii. 2 illus. N. Y., G. P. Putnam's Sons, 1930.

With the original Latin text on the left hand page and the first English translation on the right, this book is a valuable contribution to the History of Medicine. It makes easily available for the first time the original Latin text and the complete English translation of Fracastorius' "De Contagione." Fracastorius' ideas on infection were at variance with those of his contemporaries.

The book is the second volume of a History of Medicine series to be published under the auspices of the New York Academy of Medicine. Volume i, which has not yet appeared, will be "The First Books on Medicine and the Sciences, a Bibliography of Incunabula," compiled by Arnold C. Klebs.

Operative Gynecology. By Harry Sturgeon Crossen, M.D., F.A.C.S., and Robert James Crossen, M.D. Ed. 4, St. Louis, C. V. Mosby Co., 1930.

Crossen's Operative Gynecology has from its first publication been accepted by gynecologists and surgeons as a work of the highest excellence. The fact that it is now offered in its fourth edition attests these facts.

It is a well-made book of slightly over a thousand pages. It has 1246 illustrations and 2 color plates. The illustrations have been well reproduced and amplify the text. The undergraduate and hospital interne may well spend many hours slowly going through this volume. The young assistant should make it a part of his daily reading and study. The master of gynecology will review it with profit and pleasure. It is sure to offer many hints that will improve his daily routine work.

Crossen's Operative Gynecology should be in a majority of medical libraries.

Teleradiographie-Stereoradiographie, Applications Medico-Chirurgicales. By L.

Diocles. Paper, 335 p., 40 illus., Paris, Masson et Cie, 1930.

The author of this book has devoted his interest particularly to the application of stereoscopy in radiography. He has followed the work of various authors, both in France and in foreign countries, and in the historical section of the book gives adequate credit to all who have contributed to the perfection of stereoradiodiagnosis. There is an excellent discussion on binocular vision, stereoradiography and teleradiography. The author describes some ingenious improvements in apparatus, which are the result of his investigations. He highly recommends the small hand prism stereoscope for studying the films, and concludes with chapters on the application of stereoradiography to the various fields of medicine. Some beautiful examples of stereograms are included in the text.

James T. Case.

Lehrbuch der Chirurgie. By A. von Eiselsberg, Gewidmet von Seinen Schülern. Herausgegeben von P. Clairmont, H. V. Haberer, W. Denk, E. Ranzi. Redigiert von W. Denk. Vol. I, pp. 884, 389 illus. Vol. II, pp. 672, 298 illus. Berl., Julius Springer, 1930.

We have before us two volumes of a new "Lehrbuch der Chirurgie" dedicated to Prof. A. von Eiselsberg by his students. It is presumed that these two volumes form the complete work, though there is nothing to indicate this. The absence of a preface is rather surprising.

Edited by Drs. P. Clairmont, H. v. Haberer, W. Denk and E. Ranzi and with contributions by the following men: Adolf Winkelbauer, Max Sgalitzer, Egon Ranzi-Innsbruck and Fritz Starlinger, Otto Marburg and Egon Ranzi-Innsbruck, Waldemar Goldschmidt, Hans Pichler, Burghard Breitner, Gustav Hofer, Heinrich Neumann, Paul Clairmont, Wolfgang Denk, Hans v. Haberer. Leopold Schönbauer, Peter Walzel, Theodor Hryntschak and Hans Rubritius, Otto Frisch, and Rudolf Demel, the work may be looked upon as a standard representation of German surgery of today.

There are almost 700 illustrations, many of them original and all of them good.

Outline in Obstetrics for Nurses. By F. W. Rice, M.D. St. Louis, C. V. Mosby Co., 1930.

This outline represents the accumulation of notes used by the author in lecturing to nurses. It is a quick reference book, enabling both the graduate and the student nurse to get a bird's-eye view of the symptoms and treatment of a condition without stopping to read a whole chapter in a textbook. This is a very practical little book. Designed for student nurses it will, no doubt, be widely used in classrooms. Some nurses some time graduated might well spend a few hours and relearn many facts to be found in its pages.

BOOKS RECEIVED

All books received by The American Journal of Surgery are listed in this column as soon as possible after their receipt and this must be considered as adequate acknowledgment. Books that the Editor considers of special interest to our readers will be reviewed in a later issue.

Acrocyanoses (Les). By Fernand Laynai. Paris, Masson, 1929.

Anaesthesia and Anaesthetics. By F. S. Rood and H. N. Webber. N. Y., Wood, 1930.

Approaching Motherhood. By George L. Brodhead, M.D. Ed. 3, N. Y., Hoeber, 1929.

Arbeiten aus dem Neurologischen Institute. By Heinrich Obersteiner and Otto Marburg. Wien, Deuticke, 1930.

Arthrite Chronique de la Hanche (L'). By L. Duvernay. Paris, Masson, 1930.

Artificial Sunlight. By M. Luckiesh, D.Sc. N. Y., Van Nostrand, 1930.

Autonomia del Corazon (La). By Prof. Dr. Alejandro Lipschutz. Univ. de Concepcion, 1929.

Avertinnarkose in der Chirurgie (Die). By W. Anschutz, K. Specht and F. Tiemann. Berlin, Springer, 1930.

Candiru. By Eugene Willis Gudger, Ph.D. N. Y., Hoeber, 1930.

Chest in Children. By E. Gordon Stoloff, M.D. Annals of Roentgenology XII. N. Y., Hoeber, 1930.

Clinical Methods. By Robert Hutchison, M.D., F.R.C.P., and Donald Hunter, M.D., F.R.C.P. Ed. 9 N. Y., Hoeber, 1929.

Clinique et Therapeutique Chirurgicales. By George Pascalis. Paris, Doin, 1930.

Chirurgische Diathermie (Die). By H. Henseler, M.D. Berlin, Radionta, 1929.

Diagnostic et Therapeutique Electro Radiologiquest. By A. Zimmern and J. A. Chavany. Paris, Masson, 1930.

Diagnostics Urgents—Abdomen. By H. Mondor. Paris, Masson, 1930.

Dosage Tables for Roentgen Therapy. By Prof. Friedrich Voltz. Oxford, 1930.

Fonctions Hepato-biliaires (Les). By M. Chirary and F. Thiebault. Paris, Masson, 1930.

Frankfurter Zeitschrift fur Pathologie. By Prof. Dr. B. Fischer-Wasels. Munchen, Bergmann, 1930.

Fundamental Principles of Alveolo-dental Radiology. By Joseph Andrea Pollia, M.D. Brooklyn, Dental Items of Int. Publ., 1930.

Gray's Anatomy. By Warren H. Lewis, B.S., M.C. Ed. 22, Phila., Lea & Febiger, 1930.

Grundzuge der Neurochirurgie. By Walter Lehmann. Dresden, Steinkopff, 1930.

Handbook of the Vaccine Treatment of Chronic Rheumatic Disease. By H. Warren Crowe, M.D., B.CH., M.R.C.S., L.R.C.P. Oxford, 1930.

History of Haitian Medicine. By Robert P. Parsons, Lieut.-Com. M.C., U.S.N. N. Y., Hoeber, 1930.

Index of Differential Diagnosis of Main Symptoms (An). By Herbert French, C.B.E., M.A., M.D., F.R.C.P. Ed. 4, N. Y., Wood, 1928.

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A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM

EDWARD M. LIVINGSTON, M.D.

PUBLISHED SERIALLY IN

The American Journal of Surgery

TWELFTH INSTALLMENT

CONTENTS

[This Number]

	Page	A. J. S. Page
SECTION II. THE GASTROINTESTINAL TRACT (CONTINUED)	524	598
D. The Abdominal Lymphatic System (Continued)	524	598
Questionnaire	557	631
References	559	633
Eponyms	563	637
Acknowledgments	575	649

[Previously Issued]

		Vol. VIII
INTRODUCTION	1	195
SECTION I. THE CAVITY	6	200, 460 695, 912, 1110, 1325
SECTION II. THE GASTROINTESTINAL TRACT	239	1333
		Vol. IX
		156, 366, 581
		Vol. X
		169, 473

[In the following pages the Journal page number will be found at the bottom of the page.]

A CLINICAL STUDY OF THE ABDOMINAL CAVITY AND PERITONEUM*

SECTION II. THE GASTROINTESTINAL TRACT (*Continued*)

D. THE ABDOMINAL LYMPHATIC SYSTEM (*Continued*)

Enlarged intra-abdominal lymph nodes are often unexpectedly encountered during the course of abdominal operations. Their discovery calls for answers to the following questions:

1. What group of glands is enlarged; is more than one group involved; is the lymphadenopathy generalized; if a single node is implicated, to what group does this node belong?†

2. What afferent lymph vessels lead to the enlarged gland, or glands (i.e., where is the probable seat of the pathological process which caused the involvement of the nodes)?

3. What are the minute local characteristics of the lymph glands (large or small; hard or soft; movable or attached; discrete or matted)?

4. Was there anything among the preoperative data to suggest the presence of a lymphadenopathy or to offer a likely explanation as to its significance (abnormalities of superficial nodes; large spleen; history, for example, of tuberculosis; laboratory findings, such as those of leucemia; evidences of some acute infectious process)?

5. Is it advisable to remove a gland for laboratory study (biopsy)?

Sometimes a local lesion is at once seen which almost certainly accounts for the lymph node involvement (infected

* Previous installments of this book appeared as follows: Vol. viii: January issue, p. 193; February issue, p. 459; March issue, p. 693; April issue, p. 911; May issue, p. 1109; June issue, p. 1325; Vol. ix: July issue, p. 157; August issue, p. 365; September issue, p. 581; Vol. x: October issue, p. 419; November issue, p. 473.

† The terms lymph node and lymph gland will here be used interchangeably.

gall bladder; cancer of stomach). But there are other times when a primary lesion is to be found only during the course of a systematic search to ascertain the cause of the local lymphadenopathy. Knowledge of regional glandular relationships is as essential to a successful intra-abdominal exploration as to a competent preoperative physical examination. Enlarged lymph nodes within the belly should be accorded as detailed study as is routinely given enlarged cervical nodes. And it is of importance that among operative findings the characteristics of the nodes be recorded.

Location of Intra-abdominal Lymph Nodes

The location of intra-abdominal nodes is (1) about the walls of viscera, (2) along arterial trunks supplying the viscera, and (3) about the great prevertebral abdominal vessels (aorta and inferior vena cava). The major lymph node groups are the mesenteric nodes, the lumbar nodes, and the celiac nodes.

Each lymph gland, it is to be recalled, is supplied by the lymph vessels which drain a specific area (its afferent vessels); and from each node, in turn, pass off lymph vessels which go to more central parts of the lymphatic system (its efferent vessels).

Visceral Nodes

Nodes associated with individual abdominal viscera are here illustrated rather than described. But in discussions concerning the practical significance of these nodes (see acute inflammations; cancer) certain of the viscera with their intimate sets of lymph glands (visceral nodes) are dealt with at considerable length.

Mesenteric Nodes

Nodes of the mesenteric group number roughly from 100 to 150.[282] They lie between the peritoneal layers of the mesentery along the rami intestinales and vascular arcades of the superior mesenteric artery (Fig. 191 A, B). They receive their afferent vessels from jejunum, ileum, appendix, cecum, ascending and transverse colons. Efferent lymph vessels from the more proximally situated nodes unite to form a common intestinal trunk (truncus intestinalis) which enters the cisterna chyli.

Lumbar Nodes

The lumbar nodes lie behind the peritoneum of the posterior abdominal wall, upon the psoas and quadratus lumborum muscles and in close association with the abdominal aorta

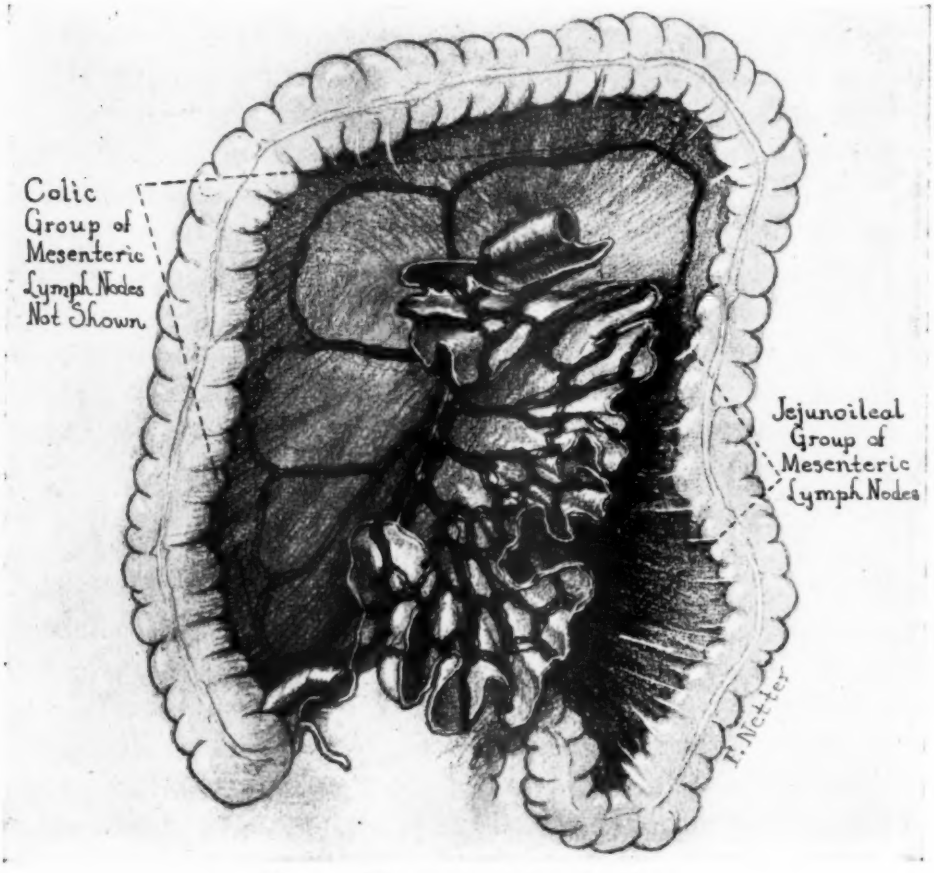


FIG. 191. The mesenteric lymph nodes.

A. Jejunoileal nodes. Note the distribution of the lymph glands along the vascular arcades of branches of the superior mesenteric artery. Observe that the course of the artery determines the direction or obliquity of the root of the mesentery. Small bowel has been cut away to show the fan-like arrangement of the mesentery and the distribution of the nodes.

and the inferior vena cava (Fig. 192). They receive afferent vessels from the lower extremities (femoral, inguinal, pubic, external iliac nodes), from the pelvis (sacral, hypogastric, common iliac nodes), from genital and urinary organs, from the posterior abdominal wall, and from part of the large

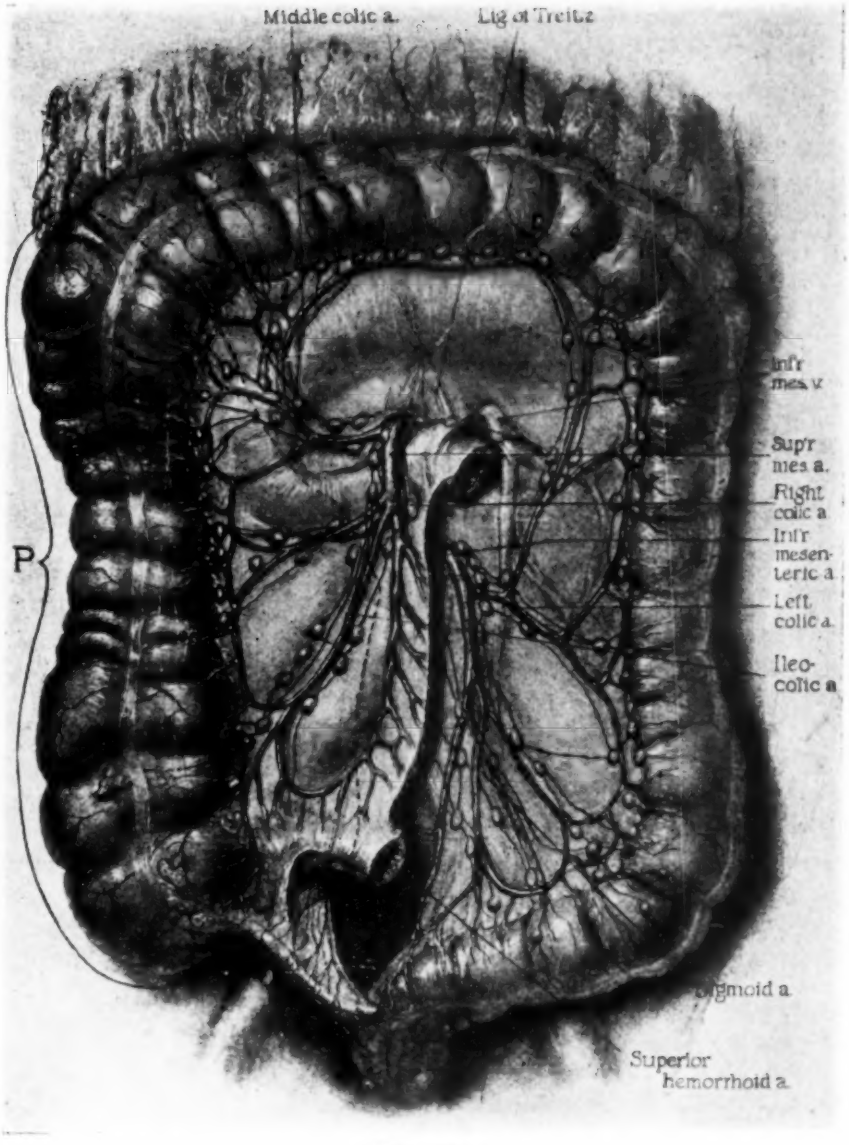


FIG. 191.

B. Colic nodes. Note distribution of lymph nodes along the inferior mesenteric, ileocolic, right, left, and middle colic arteries. The jejunoileal mesentery has been severed near its base to expose the colic vessels and nodes. (From Printy.)

intestine. The lumbar glands drain into the cisterna chyli by way of two lymph trunks, the right and left trunci lumbales.

Celiac Nodes

The celiac nodes are those in connection with the celiac

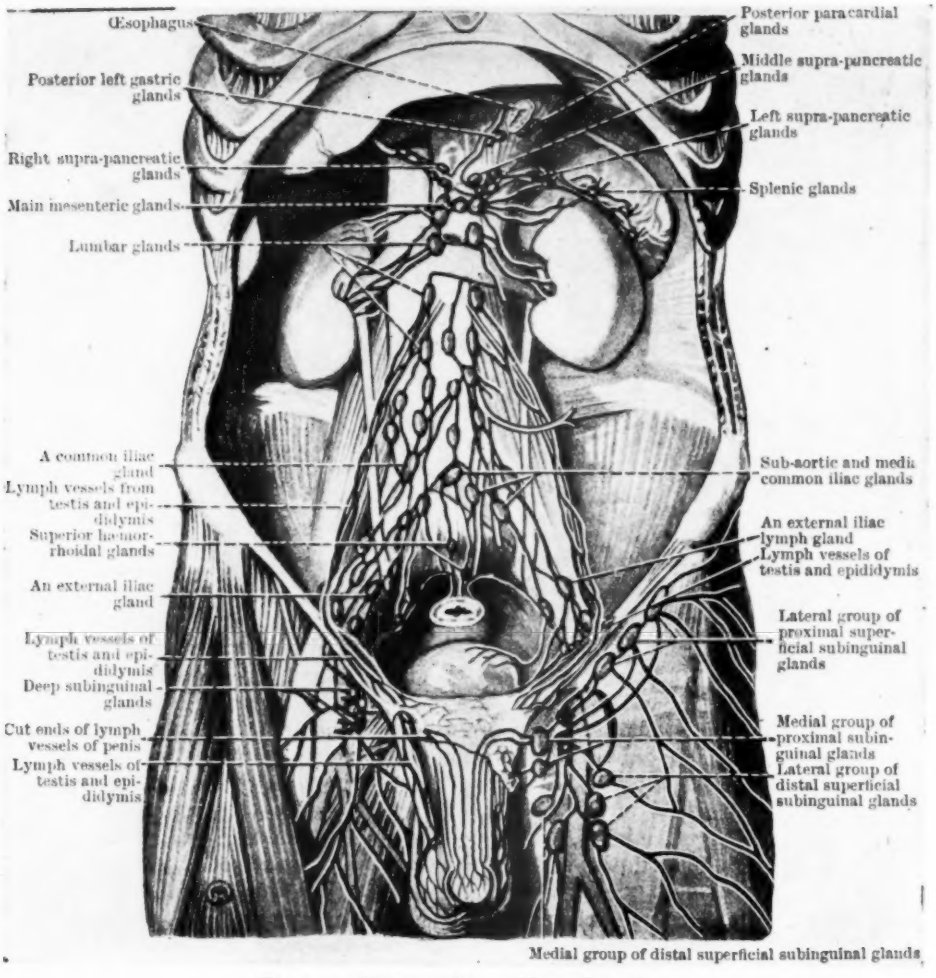

Œsophagus
Posterior left gastric glands
Right supra-pancreatic glands
Main mesenteric glands
Lumbar glands
A common iliac gland
Lymph vessels from testis and epididymis
Superior hæmorrhoidal glands
An external iliac gland
Lymph vessels of testis and epididymis
Deep subinguinal glands
Cut ends of lymph vessels of penis
Lymph vessels of testis and epididymis
Posterior paracardial glands
Middle supra-pancreatic glands
Left supra-pancreatic glands
Splenic glands
Sub-aortic and medii common iliac glands
An external iliac lymph gland
Lymph vessels of testis and epididymis
Lateral group of proximal superficial subinguinal glands
Medial group of proximal subinguinal glands
Lateral group of distal superficial subinguinal glands
Medial group of distal superficial subinguinal glands

FIG. 192. Retroperitoneal lymph nodes.

Lumbar and celiac groups of nodes showing distribution along great prevertebral vascular trunks and, in part, the drainage areas for these lymph glands. (From Cunningham.)

axis; they are few in number (15 to 20), large in size,[282] and receive the lymphatic drainage from a large part of the liver, spleen, pancreas, and stomach (*see* Fig. 192). The celiac glands through their efferent vessels drain into the cisterna

A. J. S., n. s. Vol. X, No. 3, p. 602

chyli, for the most part by way of the main intestinal lymph trunk, in common with the collected efferents from the superior mesenteric lymph glands.

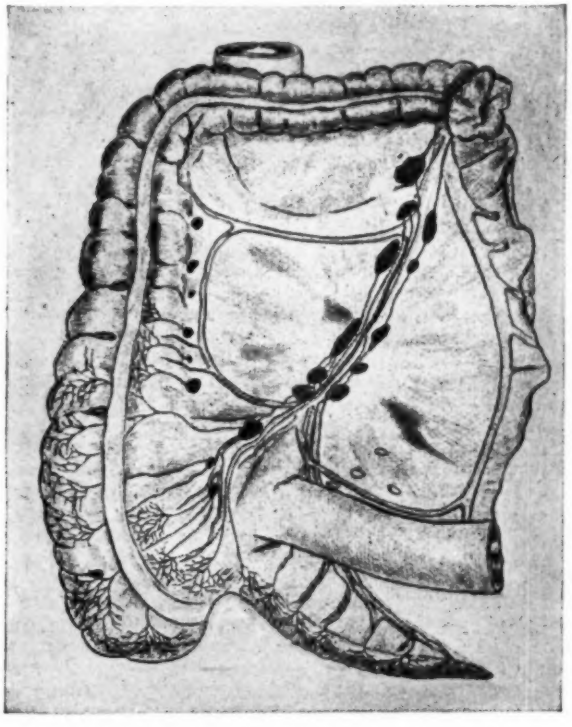


FIG. 193. Lymph vessels and lymph nodes draining ileocecal region. Note paracolic nodes, inferior, intermediate, and superior groups along ileocolic artery, with drainage toward nodes at the origin of the superior mesenteric artery from the abdominal aorta. (From Jamieson and Dobson.)

Collectively the lumbar group and celiac group constitute the so-called retroperitoneal lymph glands thus distinguishing these from mesenteric nodes.[283] Strictly speaking every intraabdominal lymph node is retroperitoneal in location for even the mesenteric nodes, situated between the leaves of the jejunoileal mesentery, are anatomically retroperitoneal.

Visualizing Lymphatic Drainage Areas

It is possible quite accurately to describe the lymphatic nodes and drainage pathways from any specific abdominal organ by first naming the small visceral groups of nodes which lie in intimate contact with various parts of the organ (see

illustrations), then the nodes along the main arteries which lead to the organ in question, and lastly the major glandular group found in closest proximity to the proximal extremity

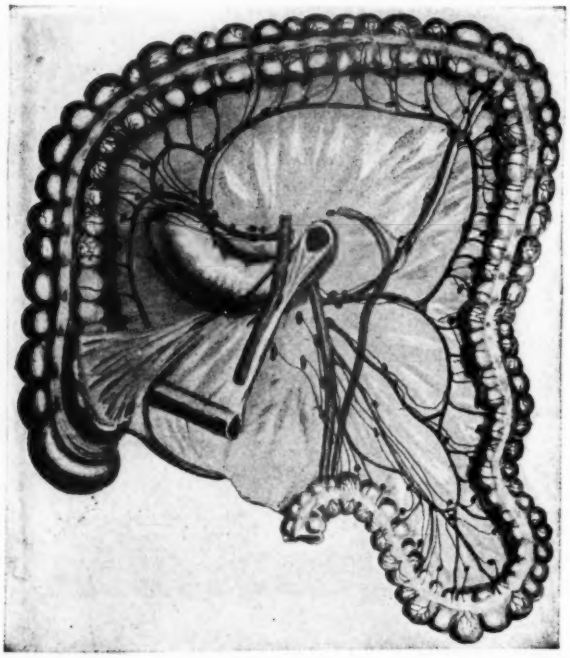


FIG. 194. Lymph vessels and lymph nodes draining pelvic colon. Observe paracolic groups, inferior, intermediate, and superior groups along the inferior mesenteric and left colic arteries. (From Jamieson and Dobson.)

of the main artery to the organ. The walls of the cecum, for example, contain afferent lymph vessels which pass into nodes lying immediately upon or along the cecal walls (anterior and posterior cecal nodes); from these nodes efferent vessels pass to the nodes along the ileocolic artery; and from these, in turn, other lymph vessels pass to more proximal nodes along the superior mesenteric artery; and the lymph flow ultimately reaches the cisterna chyli by way of the truncus intestinalis (Fig. 193). Again, the normal lymph current from within the pelvic colon passes by way of epicolic and pericolic nodes, situated near the mesocolic border of the pelvic colon, to nodes (intermediate and proximal groups)

found along the course of the inferior mesenteric artery; and thence to the cisterna chyli by way of either the right or left lumbar lymphatic trunks (Fig. 194).

Causes of Abdominal Lymphadenopathies

Intra-abdominal lymphadenopathies, as those elsewhere in the body, are most often due to:[284] acute inflammations, tuberculosis, syphilis, secondary malignancies, Hodgkin's disease, leucemia or lymphosarcoma. Of chief surgical interest are (a) inflammatory lymphadenopathies, (b) malignant lymphadenopathies, and (c) tuberculous lymphadenopathies. Intra-abdominal lymphatic enlargements due to syphilis are of relatively slight importance and treatment is medical. And if the primary or essential lymphadenomata are of surgical interest this is largely from the standpoint of differential diagnosis, since, for conditions grouped under this heading, cures by means of operations are scarcely to be anticipated.

Inflammatory Nodes and Sentinel Glands

Acute intra-abdominal inflammations, as acute inflammations elsewhere, cause associated and secondary lymphadenopathies. The nodes which must bear the brunt of the septic absorption are usually those in closest proximity to the local focus of infection. An outpost for the gall bladder is found along the cystic artery (hence along the cystic duct); and within the angle formed by the union of cystic and common ducts lies a "sentinel gland" (the cystic node). This node when enlarged is not infrequently mistaken for a calculus.[285] And care is needed, during palpation, to determine whether a small, firm, rounded or ovoid body in this region is in reality situated within or without the cystic duct. In addition to the cystic gland more remote biliary drainage glands are found along the bile ducts and hepatic artery. The normal lymphatic current is directed toward the celiac glands and the most proximal node within the biliary chain is located posterior to the head of the pancreas, close to the lower end of the common bile duct. Much work has been done to ascertain the rôle of the lymphatics in determining the relationship so often observed between cholecystitis and pancreatitis.[286] Another sentinel gland is sometimes found

within the mesoappendix. More remote nodes for the appendix are the distal, intermediate, and proximal ileocolic nodes. Still another sentinal gland is the so-called gastric node (sentinel gland of Lund (Fig. 195)).[287] This receives its afferent vessels from the proximal duodenum and pylorus. Situated in association with the right gastric artery immediately above the pylorus within the lesser omentum or hepatogastric ligament, this node is of considerable importance with reference to peptic ulcers, particularly when the ulcers are small, obscure, and easily overlooked. Similarly, just as the supraclavicular node of Troisier because of its relation to pathways of lymphatic drainage has peculiar significance in abdominal affections (particularly malignancies), and as the node of Quenu situated near the ischial tuberosity[288] bears a relationship to perirectal and other deep pelvic affections, so the cystic gland, the appendicular gland, the right gastric gland, and other individual lymphatic nodes, serve as sentinels of diagnostic value and importance to observant clinicians.

Rôle of Lymph Nodes in Altering Pathological Conditions within the Abdomen

In addition to their diagnostic significance inflamed intra-abdominal nodes may account for operative failures (secondary abscess formation; chronic complaints) and for widespread extensions from originally well localized foci (generalized peritonitis due to a ruptured lymph node). Confronted, during operation, by a supposedly acutely inflamed lymph node, the surgeon must ask himself some of the previously suggested questions (p. 524), in an effort to determine with all possible accuracy whether the tentative diagnosis is consistent with the lymphatic enlargement present. When the number, size, shape, consistency, or arrangement of the involved nodes is not consistent with the presumptive diagnosis of some single inflammatory focus, or when the character of the nodes in any way excites suspicion, some attempt should be made, from a more extended review of the lymphatic system, to reach an alternative diagnosis.

A. J. S., n. s. Vol. X, No. 3, p. 606

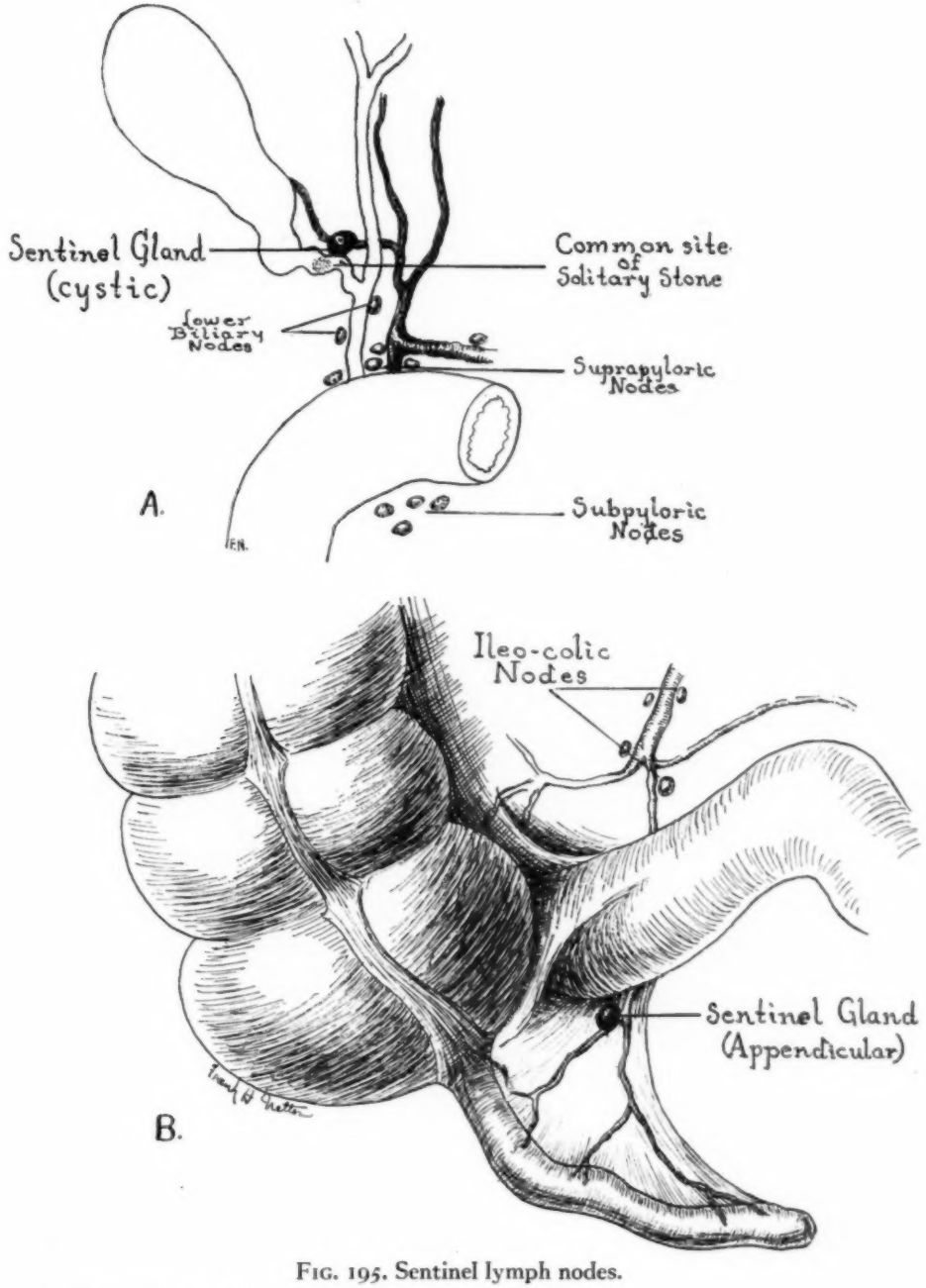


FIG. 195. Sentinel lymph nodes.

A. The cystic node.
B. The appendicular node.

A. J. S., n. s. Vol. X, No. 3, p. 607

Malignant Metastases Due to Lymph Permeation

Secondary malignant lymphadenopathies are caused by lymph permeation or lymphatic embolus formation. By lymph permeation is meant the development along lymph channels of a continuous chain of malignant cells leading from the primary tumor to the involved node. This process has been shown to account for extension of cancer into the abdominal cavity from without,[289] for example, involvement of nodes along the falciform ligament of the liver from a primary tumor of the breast. It also explains certain cases of malignant spread from intra-abdominal organs to the body surface, such for example, as the invasion of supraclavicular nodes from a primary tumor of the ovary (Fig. 196). The results of microscopical studies concerning the phenomenon of lymph permeation are visually depicted in accompanying illustrations which show to what remote regions tumor cell-chains may extend.

Metastases Caused by Malignant Emboli

There seems clear-cut evidence that clusters of malignant cells also move along lymph channels in the form of emboli,[290] lodging as a rule in the first lymph node filters to be encountered (Fig. 197). Malignant emboli may reach the cisterna chyli and thoracic duct, to pass at the base of the neck into the venous circulation. Certain clinically observed malignant metastases would prove difficult to explain except upon the basis of such a secondary invasion of the blood stream.

Proved Routes of Extension

Because of the serious import of a secondary deposit of malignant cells along a lymph channel or within a lymph node it proves necessary, in order to effect a surgical cure, that every vestige of malignant tissue be excised. Hence, operations for the removal of malignant growths in reality represent studies in the surgical anatomy of the lymphatic system.[291] This presupposes that surgeons possess precise knowledge as to all usual and likely pathways for extension. By means of post-mortem studies this incidence of invasion of every group or subgroup of nodes has been worked out for each common intra-abdominal malignancy. Danger points have been accurately determined. The extent of necessary

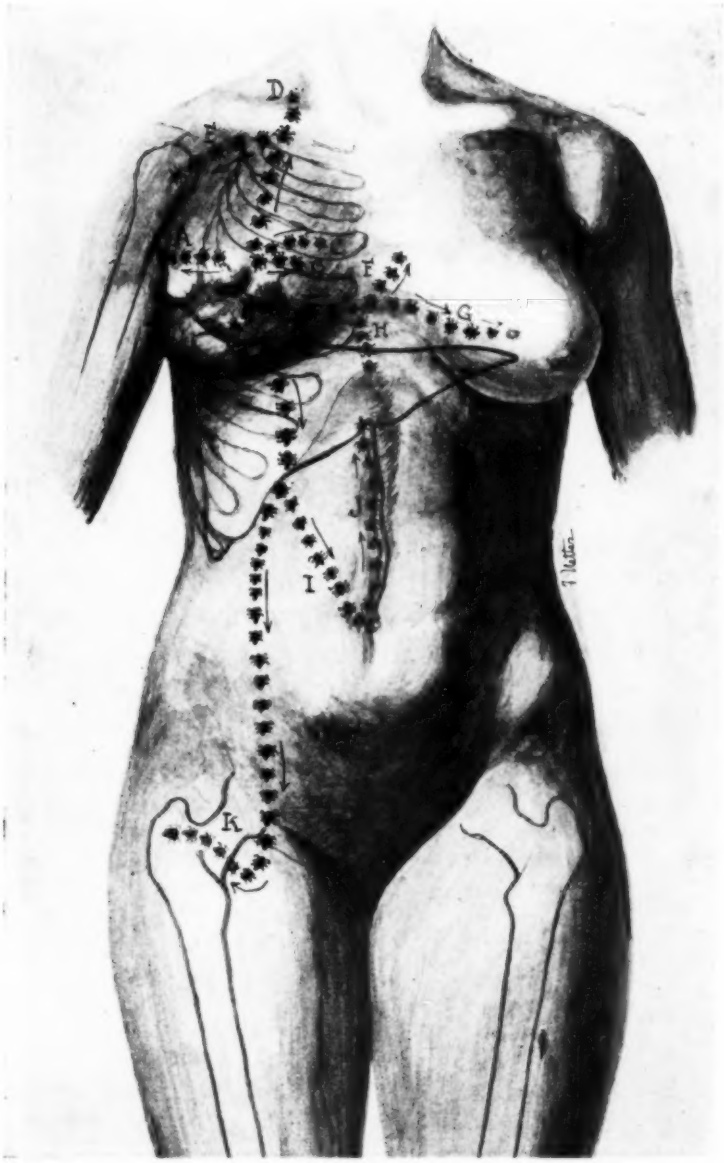


FIG. 196. Lymph permeation.

Method of malignant extension along lymphatic vessels by solid cellular chains.

Primary malignancy of right breast (note retraction, elevation, and deformity of breast) with extensions through lymph permeation: A, to axilla; B, to intercostal nodes; C, to mediastinal nodes; D, to supraclavicular nodes; E, to head of humerus; F, G, to opposite side of thorax; H, to epigastric nodes; I, to umbilical nodes, and J, along falciform ligament to liver; K, to inguinal nodes and to neck of femur.

The abdomen is invaded through routes H, I, and J.

excisions is known. Two factors indicate that it is necessary to make excisions more extensive than might at first seem required. The first factor is this: not all the afferent lymph channels from a primary site lead to the node or nodes nearest the growth. Some pass without interruption to more distant lymph glands. Thus an early lymph node metastasis from an ileocecal carcinoma may be situated, not in close proximity to the primary tumor, but near the point at which the ileocolic artery springs from the superior mesenteric artery; a node in this location may show undoubted microscopic evidences of involvement while the intermediate, and the distal ileocolic nodes remain free from tumor cells. The second factor which indicates the necessity for wide excisions is that normal lymphatic pathways often become obstructed by tumor cells, causing a reversal of the lymph current with a flow to collateral routes. This results in the formation of metastatic tumors in unexpected regions (aberrant implantations) Malignant plugging or obstruction of the normal lymphatic route from cecum to nodes along the ileocolic artery not infrequently causes metastases to appear within juxtaintestinal nodes of terminal ileum and ascending colon. And although the primary tumor never extends any great distance along the alimentary canal it is necessary, when dealing with an ileocecal carcinoma, to remove several inches to terminal ileum and a large part of the ascending colon. The limits of necessary intestinal excisions are determined in part by the presence of involved lymph nodes along the bowel walls and in part by the distribution of arteries which must be ligated. The points of arterial ligations, in turn, are predetermined by the presence along major vessels of common sites for glandular metastases. (Fig. 198.)

Plans for Malignant Excisions

Operations for the removal of gastrointestinal malignancies have been mapped out upon the basis of proved routes of lymphatic spread as determined by the study of necropsy material and of tissues excised during operations. The removal of lymphatic structures en bloc necessitates at times the liga-

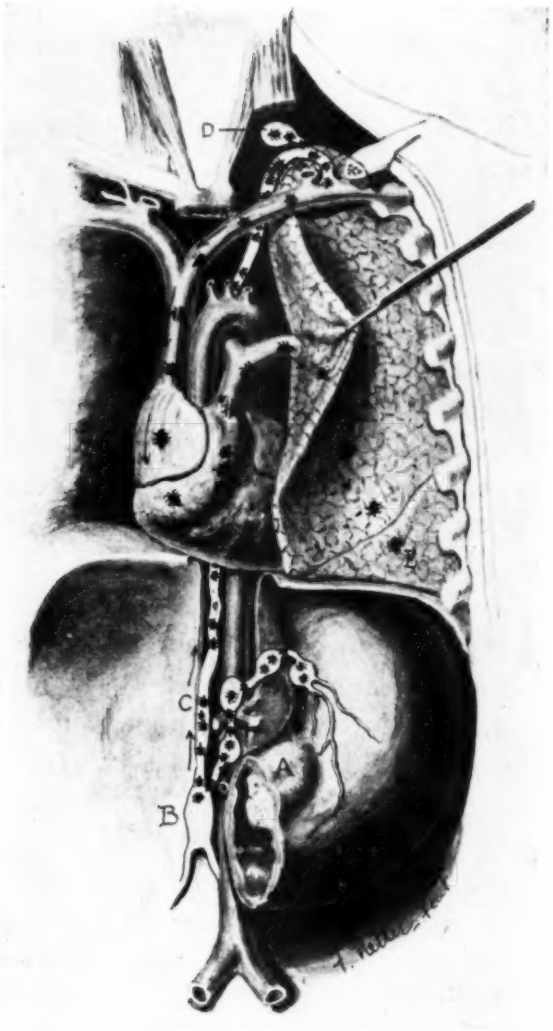


FIG. 197. Malignant emboli.

Clusters of malignant cells originating at primary tumor of stomach (A) travel along afferent lymph vessels to anterior left gastric nodes, to posterior left gastric, coronary, celiac, and superior mesenteric nodes. By way of the truncus intestinalis they enter the cisterna chyli (B), travel upward along the thoracic duct (C), and enter the systemic venous circulation at the left side of the base of the neck; traversing the innominate vein they enter the right auricle of the heart; passing through the right ventricle and pulmonary artery the cells are desposited in the tissues of the lung where secondary or metastatic nodes grow. At D is seen a Troisier or Virchow-Troisier gland (situated behind sternal head of left sternomastoid muscle) an important sentinel node for intra-abdominal malignancies. Clinically the nodes near the stomach are practically always involved, the cervical nodes are rarely involved while involvement of pulmonary tissues from a gastric neoplasm is a great rarity.

tion of important arteries because of the proximity to these vascular trunks of lymph nodes which it might prove dangerous to leave behind; and this makes necessary the excision also of such segments of the intestinal tract as are thus to be deprived of their arterial blood supply. Accompanying figures illustrate some of the operations proposed by various authorities (Figs. 198 and 199). The statement appears quite true that surgery for gastrointestinal malignancies is the surgery of the gastrointestinal lymphatic system.

Cancer of the stomach is the most common malignant disease affecting the male. To review salient facts concerning the operative management of this condition further focuses attention upon the anatomy of abdominal lymphatics and serves to give additional emphasis to general principles involved in the surgical treatment of malignant neoplasms.

Gastric Lymph Nodes

Gastric lymph nodes, according to a previously stated rule, follow roughly the distribution of gastric arteries. But the gastric arteries spring from trunks which supply as well as the stomach other important viscera of the supracolic division of the peritoneal cavity. Blood to the right extremity of the stomach comes from branches of the hepatic artery; and blood to the left half of the greater curvature comes from branches of the splenic artery. Similarly many of the gastric lymph nodes serve as drainage filters for other viscera as well as for the stomach. This intimate association of the lymphatic drainage basins from upper abdominal organs seems, upon first consideration, to render the study of gastric lymphatics complex. The complexity, however, is largely one of nomenclature and is more apparent than real. The situation is clarified by first studying gastric nodes solely in their relation to gastric circulation without reference to confusing names which tend to obscure this association of nodes and arteries.

The immediate or primary lymph drainage of the stomach is to nodes situated directly upon or in close juxtaposition to gastric walls; the more remote or secondary lymph drainage is to nodes located along the vascular trunks of the celiac

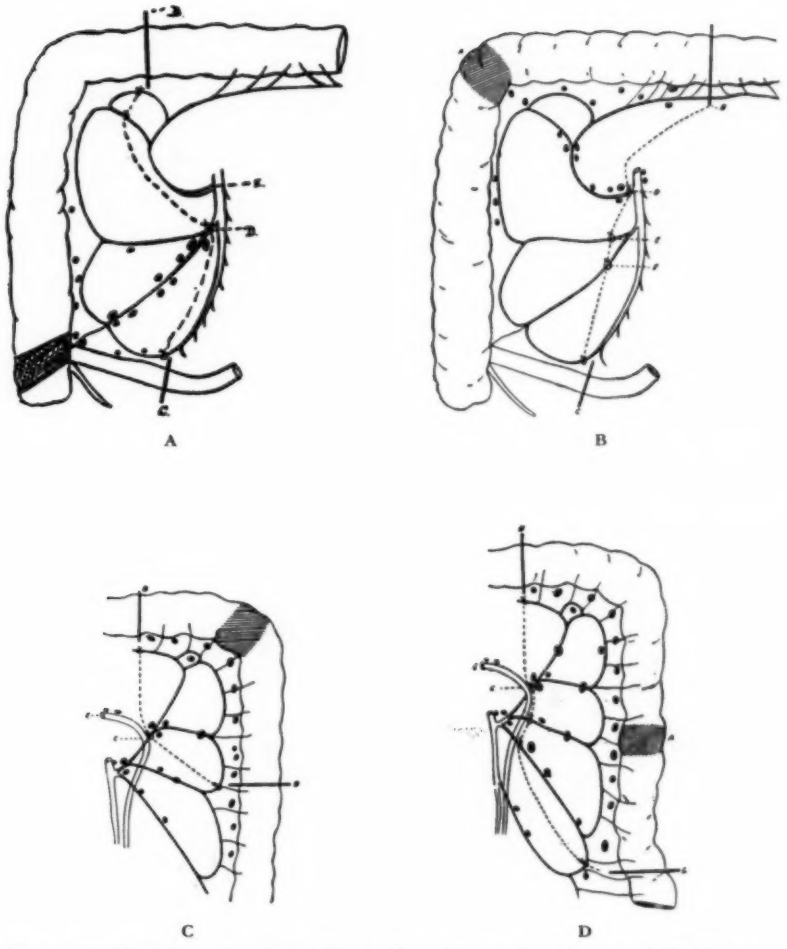


FIG. 198. Excision of colic malignancies. (From Jamieson and Dobson.)

A. Excision of cecal growth.

A, growth; *B*, line of section of colon; *C*, line of section of ileum; *D*, point of ligature of ileocolic artery; *E*, point of ligature of middle colic artery.

B. Excision of growth at hepatic flexure.

A, growth; *B*, line of section of transverse colon; *C*, line of section of ileum; *D*, point of ligature of middle colic artery; *E*, point of ligature of right colic artery; *F*, point of ligature of ileocolic artery.

C. Excision of growth in splenic flexure.

A, growth, *B*, line of section of transverse colon; *C*, point of ligature of left colic artery; *D*, line of section of descending colon; *E*, inferior mesenteric vein.

D. Excision of a growth in the descending colon.

A, growth; *B*, line of section of transverse colon; *C*, point of ligature of left colic artery; *D*, line of section of sigmoid flexure; *E*, inferior mesenteric vein.

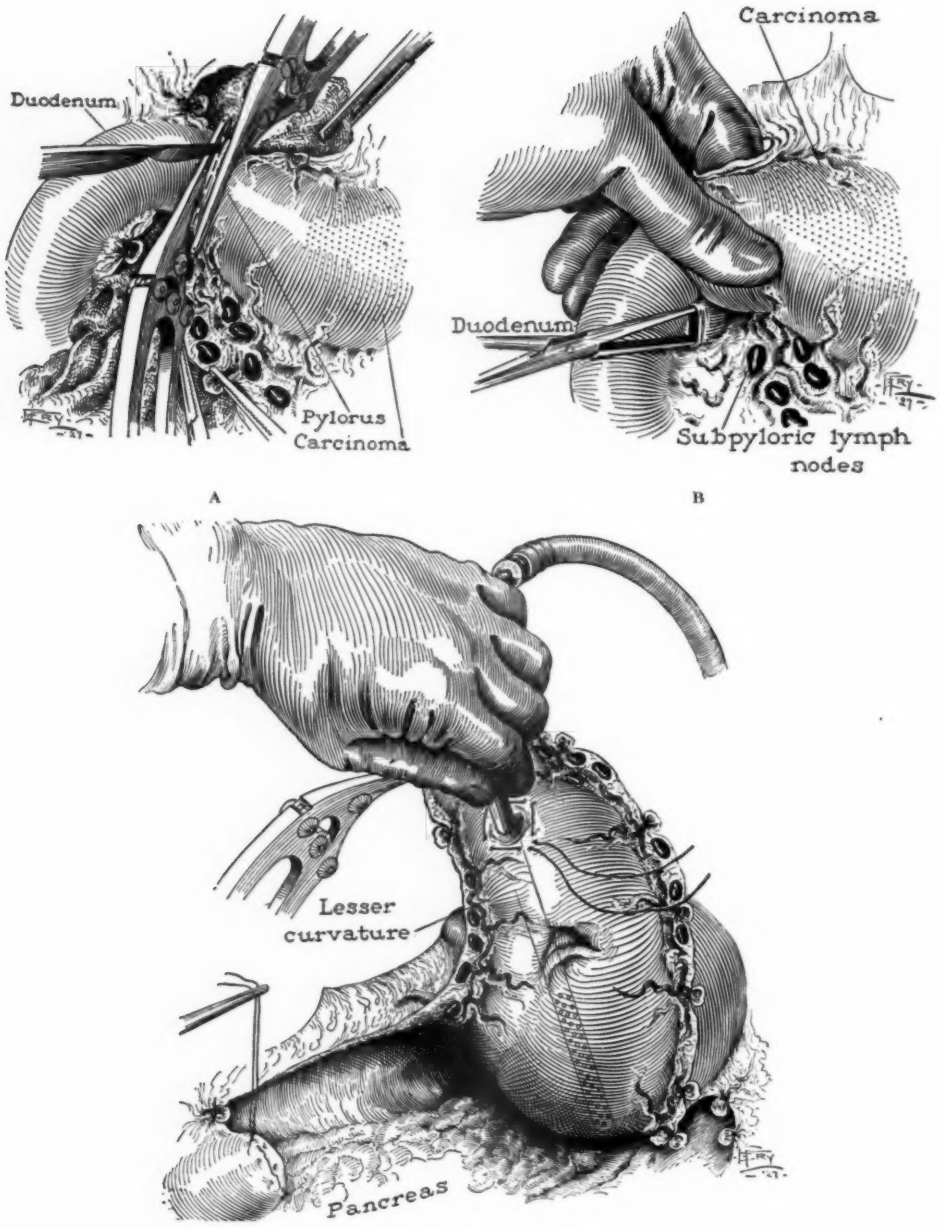


FIG. 199. Gastrectomy for excision of malignant tumor. (From Balfour.)

Note emphasis upon removal of gastric lymph vessels and nodes.

A and B show method for mobilizing subpyloric, suprapyloric, and retropyloric nodes with the stomach.

C shows gastroepiploic, subpyloric, retropyloric, and suprapyloric nodes, anterior and posterior left gastric nodes all being removed with gastric mass.

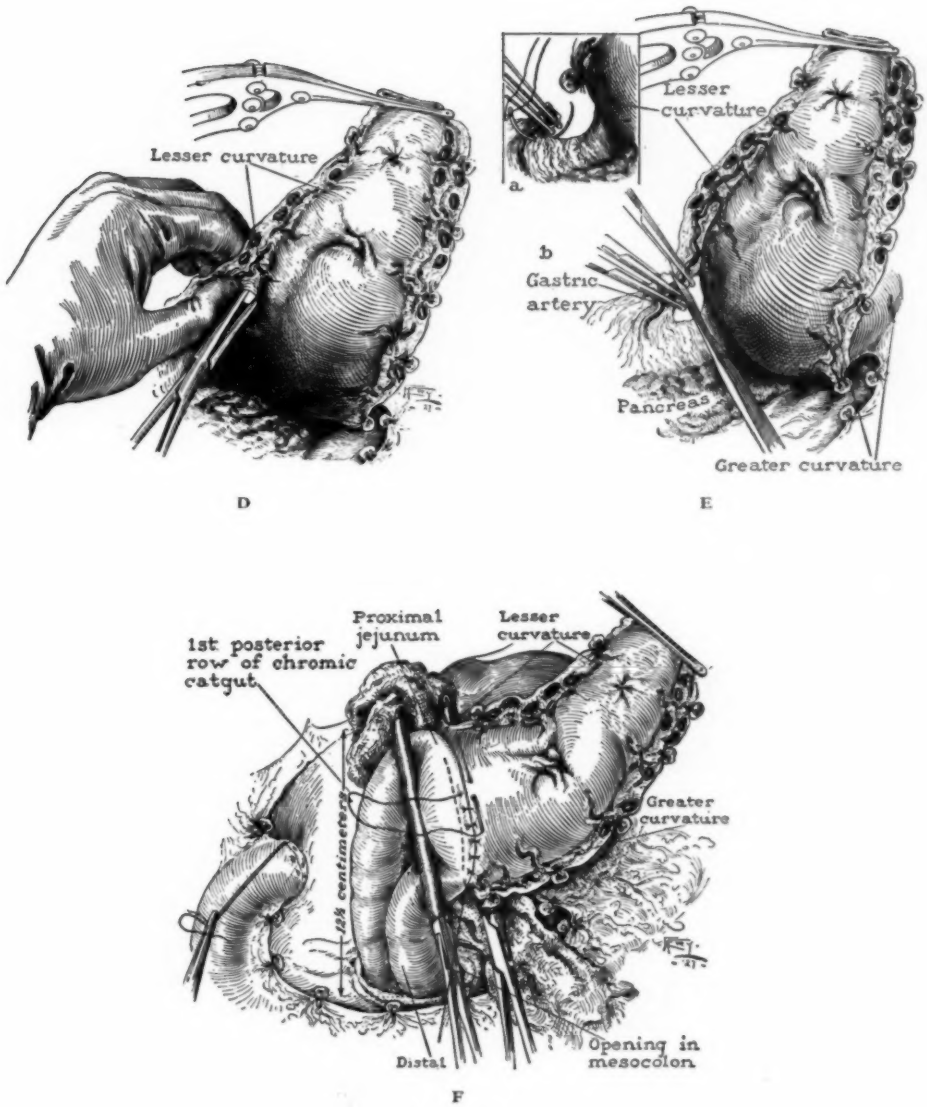
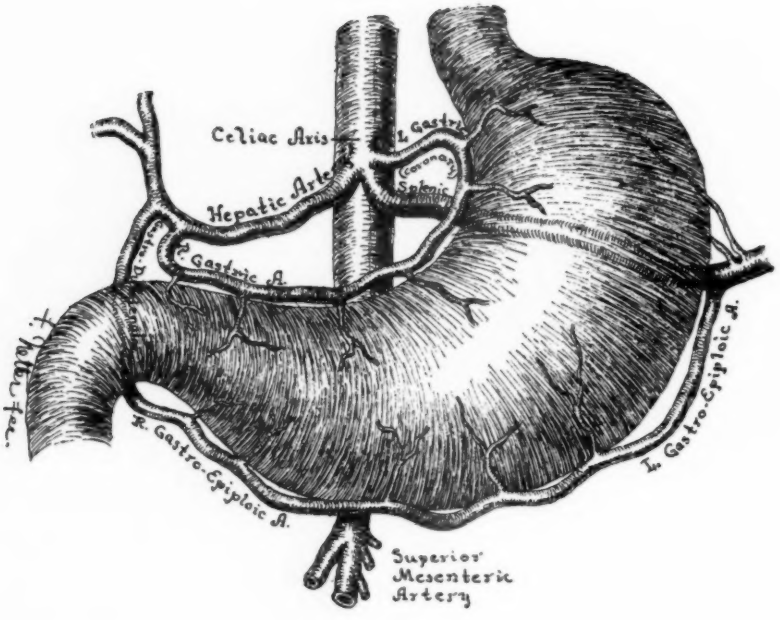


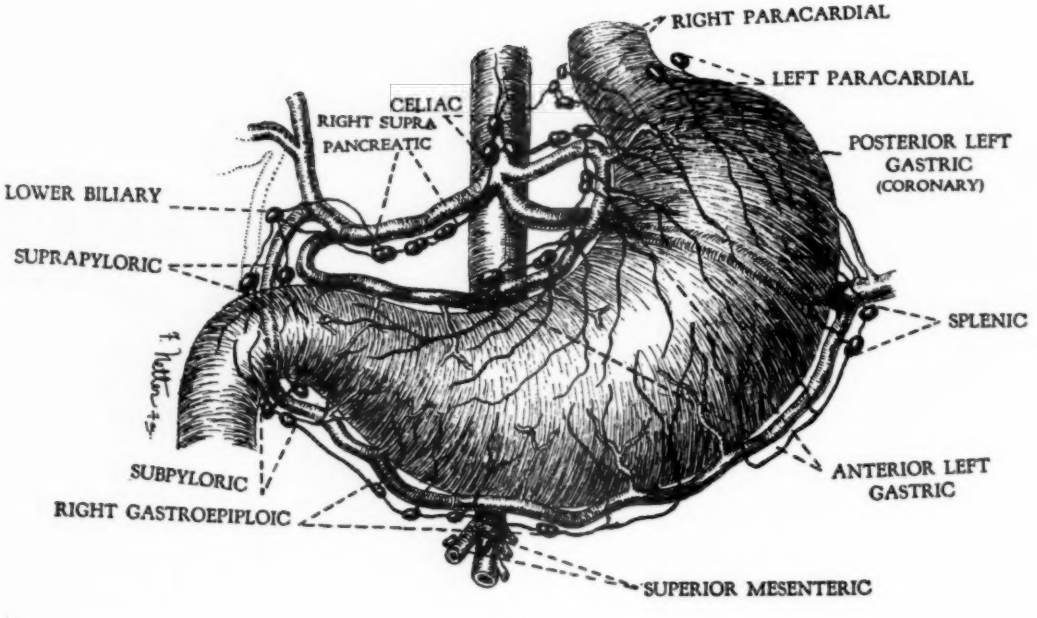
FIG. 199.

D and E. Ligation of the left gastric artery as it approaches the lesser curvature within the left gastropancreatic fold. Were ligation made along the lesser curvature the left posterior gastric glands would remain.

F. A loop of jejunum has been drawn through the transverse mesocolon and an anastomosis of stomach and jejunum (posterior Polya type) is being made prior to the removal of the malignant tissue and associated lymphatic structures.



A



B

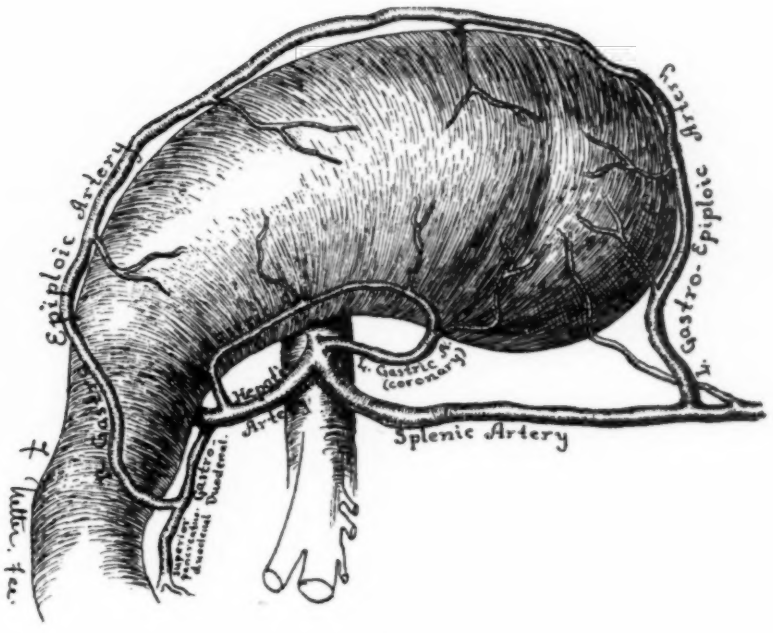
FIG. 200. A study of gastric lymph vessels and lymph nodes.

The primary (visceral) and secondary groups of gastric lymph nodes are distributed along the branches of the gastric arteries.

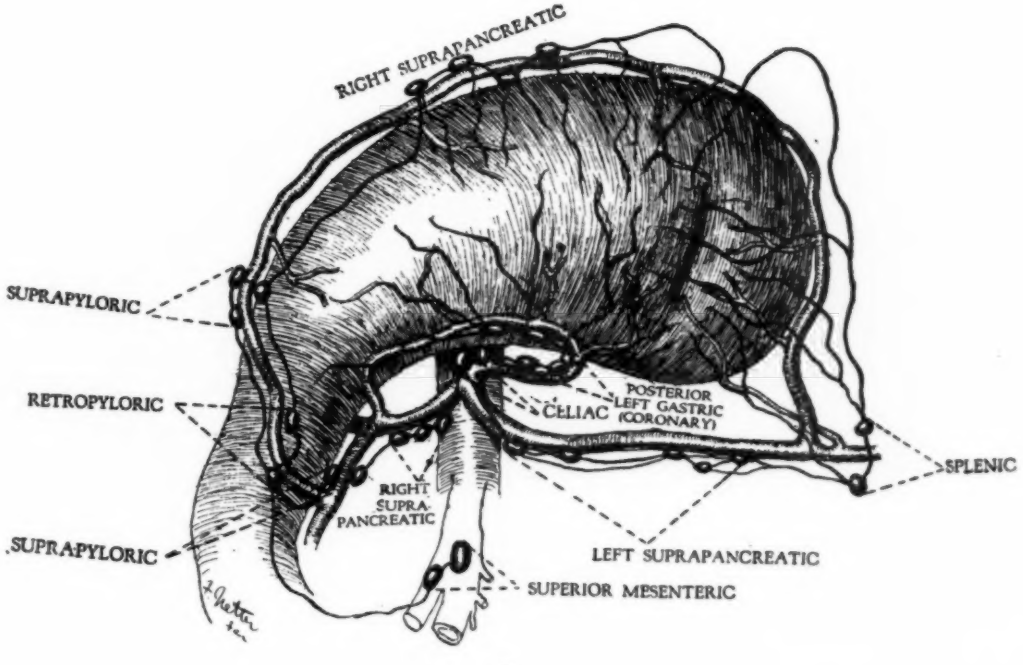
A. Anterior view of stomach and gastric arteries.

B. Relation of lymph nodes to gastric arteries.

A. J. S., n. s. Vol. X, No. 3, p. 616



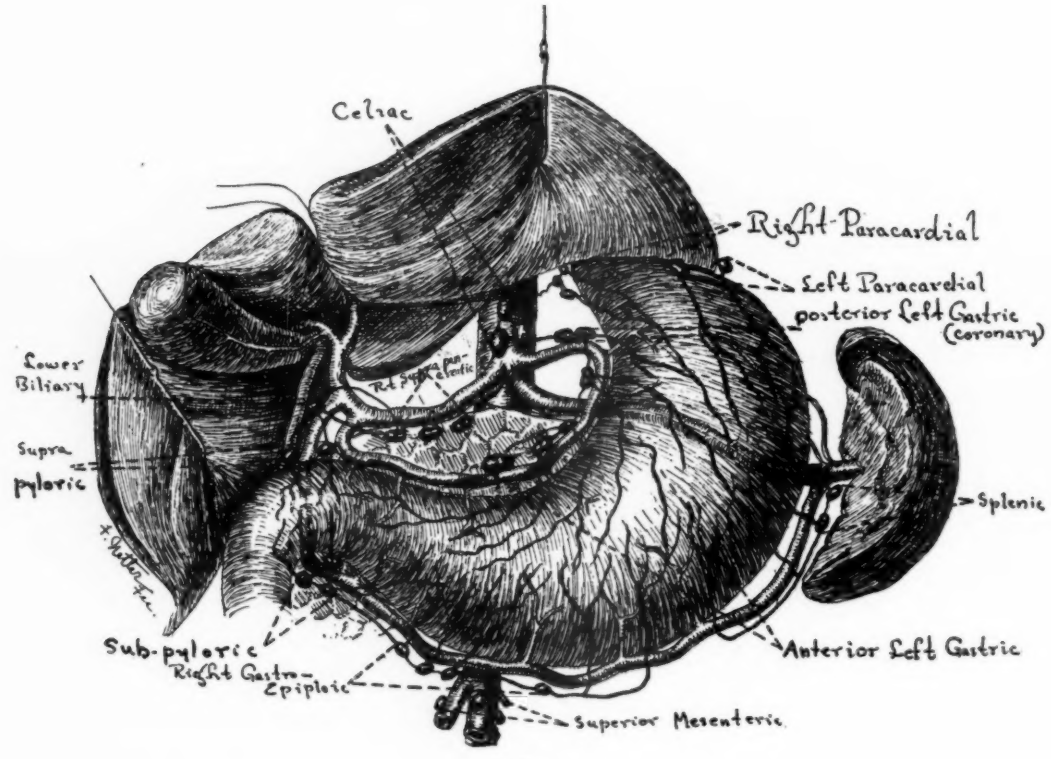
C



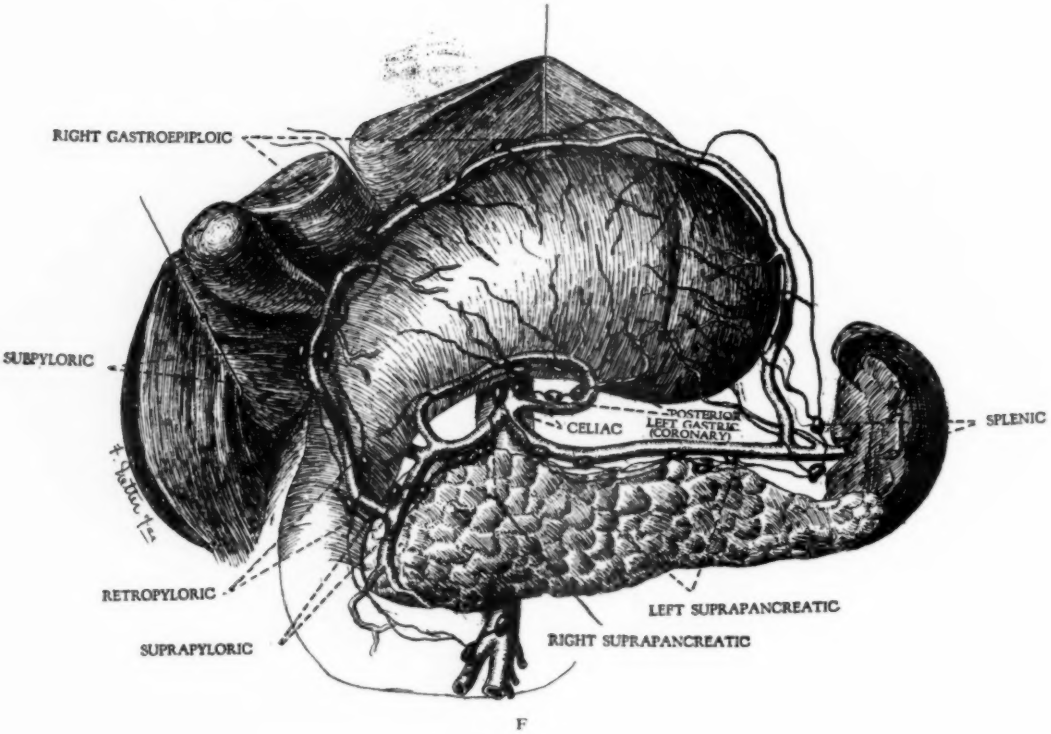
D

FIG. 200.

C. Posterior view of distribution of gastric vessels (stomach rotated upward).
D. Posterior view of gastric lymph vessels and lymph nodes.



E



F

FIG. 200.

Figures E and F show the adjacent viscera and explain the names given the secondary gastric lymph nodes. Confusing nomenclature should not obscure the relationship between gastric arteries and gastric lymph nodes.

E. Anterior view of gastric lymphatic structures with their relationship to adjacent viscera of the supracolic division of the peritoneal cavity.

F. Posterior view of gastric lymphatic structures showing relationship of lymph nodes to adjacent upper abdominal viscera.

axis which supply the stomach with arterial blood (i.e., along right gastric artery, the hepatic artery and the splenic artery). Could one but ignore the fact that there is within the upper abdomen a liver, a pancreas, and a spleen this arrangement of the primary and secondary lymph nodes of the stomach would be extremely simple (Fig. 200a). And the gastric lymphatics could easily be described according to the method previously stated of naming first the lymph nodes associated with the visceral walls, second those along the artery or arteries supplying the viscus, and finally the large lymph node group situated nearest the origin of the artery or arteries in question (in this case the celiac cluster of retroperitoneal nodes situated about the celiac axis) (Fig. 200b). Because of the presence of pancreas, liver, and spleen, however, the secondary gastric lymph nodes take their names from their nearness to these other organs. The secondary gastric nodes, it is to be observed, serve as primary drainage nodes for adjacent viscera (Fig. 200c). Thus the secondary nodes along the gastroduodenal artery lie in anatomical relation to the terminal portion of the common bile duct and form part of the lymph node chain known as "biliary nodes." Again, the secondary gastric nodes along the hepatic artery lie in anatomic relation to the upper border of the pancreas and are therefore termed the supra-pancreatic lymph nodes.

This foregoing viewpoint and explanation may, or may not, make the routine description of gastric lymphatics as stated in anatomical textbooks more readily understandable:[292]

> The lymph vessels of the region of the pyloric canal pass (*a*) partly to the anterior left gastric glands, (*b*) partly to the right suprapancreatic lymph glands, and (*c*) partly to the lower biliary group of lymph glands. If the right gastric gland is present some of the vessels of the upper pyloric region go to it, and in some cases vessels from the pyloric region pass directly to the posterior left gastric lymph glands.
>
> The lymph vessels from the right upper area of the larger portion of the stomach pass (*a*) to the anterior left gastric lymph glands, (*b*) to the posterior left gastric lymph glands, (*c*) to the paracardial lymph glands.
>
> The lymph vessels from the left section of the left and lower portion of the stomach pass along the gastrosplenic ligament to the splenic glands,

which are occasionally present near the hilum of the spleen, and partly to the left suprapancreatic lymph glands.

The lymph vessels from the right part of the lower and left area follow the course of the right gastroepiploic artery and terminate in the subpyloric glands.

The practical problems are to learn what lymphatic vessels and lymph nodes theoretically should be removed in order to obtain surgical cures, and to know which of these particular structures can and which cannot, be removed with safety to life. Among recorded statements concerning the abdominal lymphatics in relation to cancer of the stomach are the following:[293–296]

Glandular metastasis with cancer of the stomach is of very early occurrence.

Primary gastric nodes are always involved by the time of death from cancer of stomach.

The study of gastrectomy specimens shows that in more than 90 per cent of instances lymph nodes along the lesser curvature are already involved by cancer cells at the time of operation; and that nodes along the greater curvature are involved in over 60 per cent of instances.

Malignant disease at the pylorus tends to spread toward the cardiac end of the stomach, especially along the lesser curvature.

Lymph Nodes with Gastric Carcinoma

Whereas detection of glandular involvement upon the basis of macroscopic findings (size, consistency) is often assumed to be reliable, it is known that many times the enlarged and apparently involved nodes represent simply an inflammatory lymphadenopathy.

Enlarged nodes may prove non-malignant while apparently normal nodes may, upon microscopic examination, prove to be filled with cancer cells. Hence enlargement of nodes in connection with cancer is not a reliable index of inoperability.

There is comparatively little direct lymphatic communication between the stomach and the duodenum, for, although the submucous and subserous layers of both organs are

richly supplied by lymph spaces, at the pylorus itself, because of a condensation of the connective tissue, the lymphatics are poor in character and few in number, reducing to a minimum the lymph-vascular connection between these adjacent structures.

The glandular groups which should surely be removed with a malignant growth at the pylorus are: the suprapyloric nodes, the subpyloric nodes, the retropyloric nodes, the right paracardial nodes, the nodes along the left gastric artery as it approaches the stomach within the left pancreaticoduodenal fold or falx coronaris (coronary nodes; left anterior gastric nodes; left posterior gastric nodes), the right gastroepiploic nodes, and the right suprapancreatic nodes.

While some lymph vessels from a primary site go to nodes immediately adjacent to the tumor, other afferent vessels from the same primary site pass directly to more distant nodes.

The left gastric artery should be ligated as it approaches the stomach rather than along the lesser curvature, in order that the important nodes along the artery within the left gastropancreatic fold may be removed en bloc with the specimen (coronary nodes; left anterior gastric nodes; left posterior gastric nodes).

The right suprapancreatic nodes are not so close to the malignant growth as they might appear in illustrations, for the pancreas is separated from the stomach by the retrogastric bursa or lesser peritoneal cavity and the lymph current must follow the course of the hepatic artery to reach the pancreatic nodes. Even when stomach and pancreas are adherent, after obliteration of the bursa omentalis, the lymphatic pathway is still chiefly along the para-arterial channels.

Involvement of the splenic lymph nodes is rare, due to the relative infrequency of malignant involvement of the cardiac extremity of the fundus; but when these nodes are infiltrated an operative cure is scarcely to be expected unless the spleen is removed together with the gastric malignant tissue.

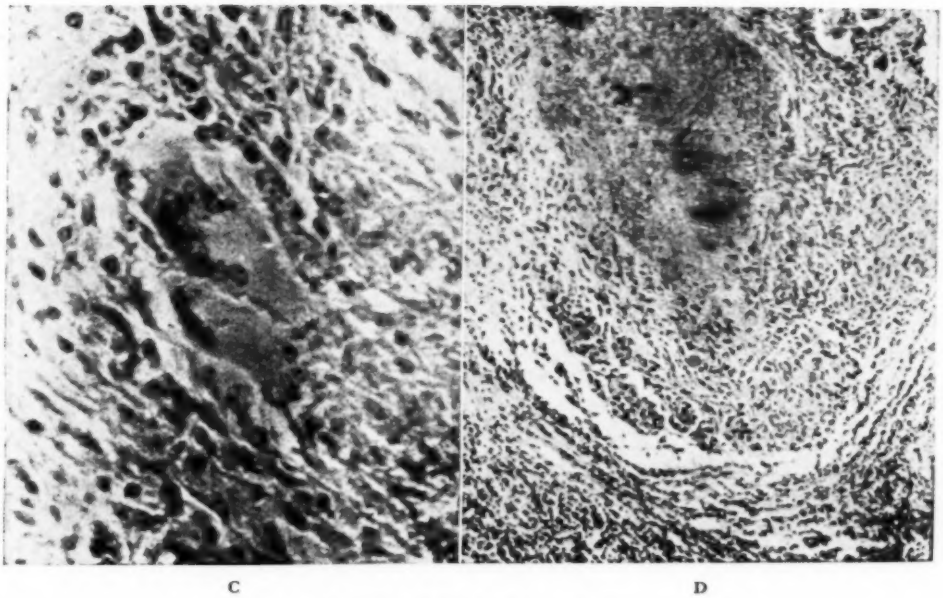
A few glands of the subpyloric group drain secondarily along the upper border of the terminal portion of the duodenum to reach the nodes of the superior mesenteric group. Malignant extensions to these nodes, as to those immediately adjacent to the celiac axis, render the case almost certainly inoperable.

Practically the entire lymphatic drainage of the stomach ultimately reaches the celiac nodes, i.e., the upper major group of the retroperitoneal division of the intra-abdominal lymph glands.

Tuberculosis of the Mesenteric Nodes

Tuberculous involvement of the intra-abdominal lymph nodes may take the form of a localized process, a few nodes only being implicated, or of a diffuse and widespread invasion. The site of election is the ileocecal region. Here the lymph nodes drain a portion of the absorptive division of the bowel which is especially rich in lymphoid tissue (Peyer's patches). Even when involvement is diffuse it is almost always first and foremost the mesenteric nodes, rather than the lumbar or celiac nodes, which are implicated; for the gastrointestinal tract is the usual atrium for infection. Tuberculosis within the abdomen is most often of the bovine type.[297] The characteristics of individual tuberculous glands have already been described and explained (pale, cool, soft; see p. 513). Matting and caseation are as common within the abdomen as elsewhere. Tuberculous lymph glands are frequently associated with other forms of abdominal tuberculosis such as tuberculous enteritis, tuberculous seminalvesiculitis or salpingitis, and tuberculous peritonitis. Of the three common forms of the latter condition (serous, fibrinous, and locular or suppurative) it is chiefly the locular form in which enlarged nodes constitute an outstanding feature (Fig. 201). Caseating nodes frequently form the center of a locule. Lymph-glandular rupture is followed by a free distribution of miliary tubercles upon adjacent surfaces of bowel, omentum and peritoneum. Lymph gland involvement alone, however, is sometimes observed. This is the most mild form of intra-abdominal tuberculosis.

A B



C D

FIG. 201. Tuberculosis of abdominal lymph nodes.

A and B. Caseating tuberculous lymph glands. (From Edmunds.)

C. Giant cells within a tuberculous lymphatic gland. (From Edmunds.)

D. Caseating tuberculous lymphadenoma. (From Edmunds.)

Spontaneous recovery, it is said, may be anticipated in more than 50 per cent of cases of this condition.[298] Lymph node tuberculosis, when more advanced and serious in character has been

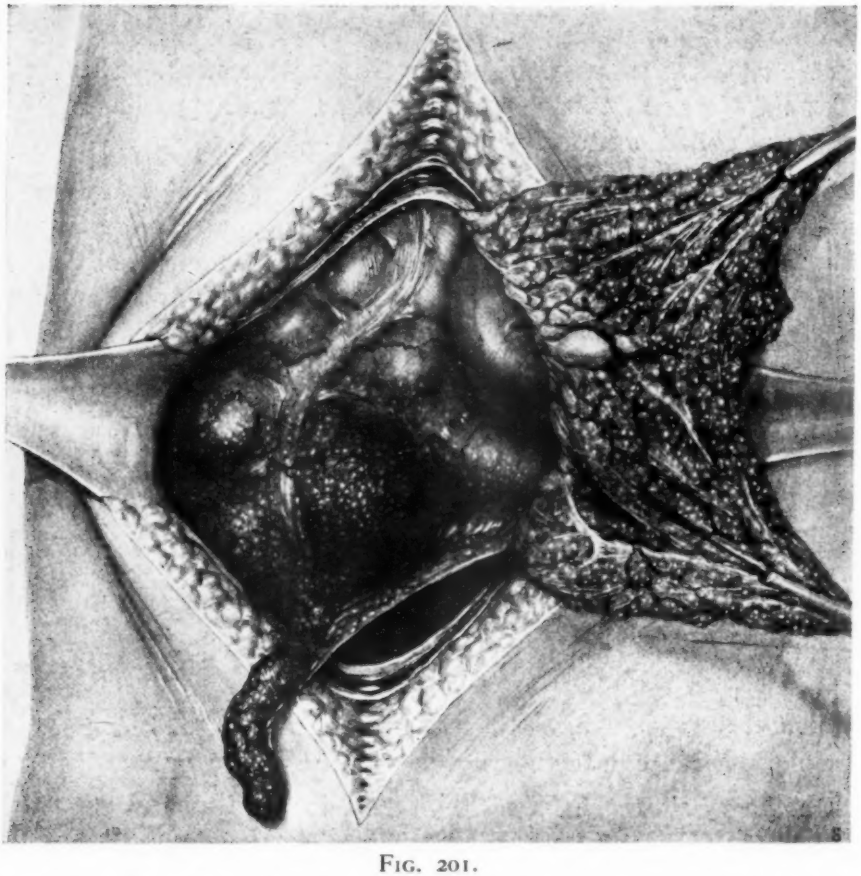


FIG. 201.

E. Acute miliary ileocecal tuberculosis. Enlargement of mesenteric lymph nodes is an important part of the pathological picture with this condition. The great omentum (drawn out of wound) contains innumerable miliary tubercles. (From Hertzler's The Peritoneum, Mosby.)

termed Tabes Mesenterica (from tabes, a wasting). The terms tabes mesenterica and tabes dorsalis are not to be confused. With tabes dorsalis the wasting is due to involvement of the posterior spinal columns and posterior root ganglions, the cause being usually, if not always, syphilis. But in tabes mesenterica the wasting is an expression of

malnutrition from interference with normal fat absorption by way of the lymph vessels; it is an index also of toxic absorption caused by the action of the tubercle bacilli upon the tissues

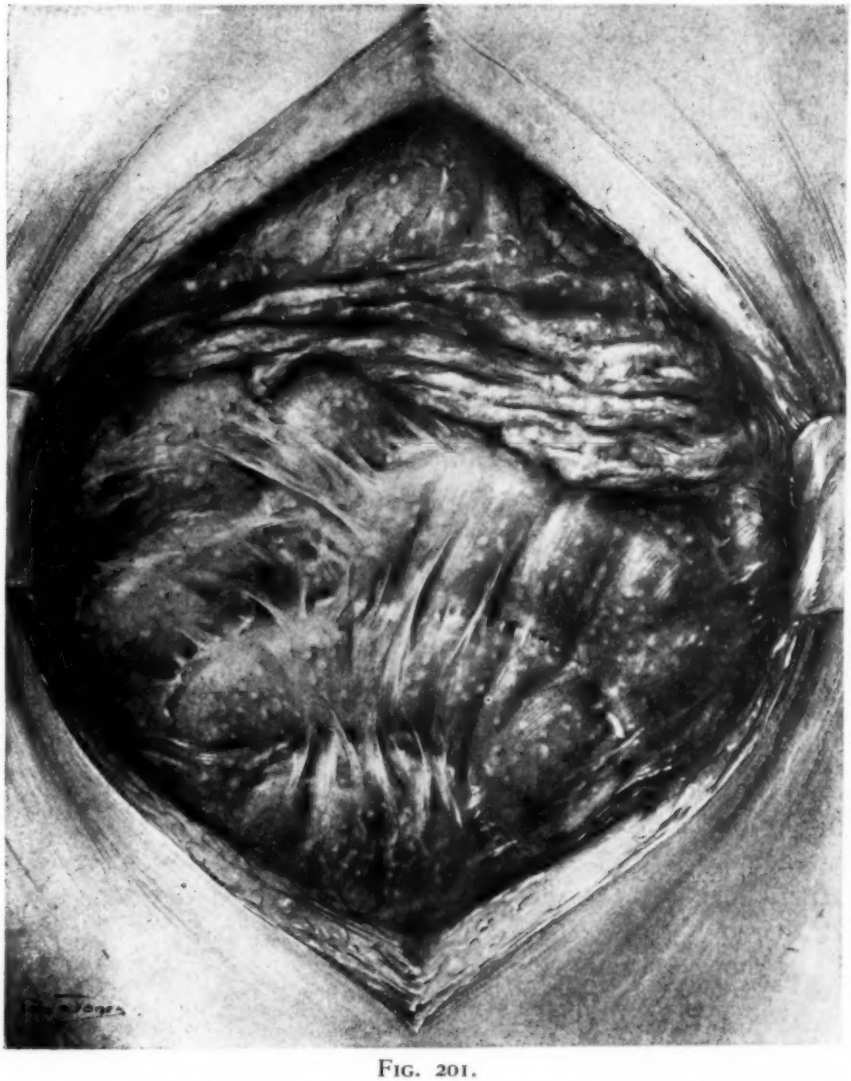


FIG. 201.

F. Fibroadhesive tuberculous peritonitis. Rupture of tuberculous mesenteric lymph nodes may lead to such an extensive or generalized pathological process. (From Hertzler's The Peritoneum, Mosby.)

of the host, an action which causes typical emaciation with tuberculous processes as they occur in any part of the body (consumption, to use up or waste; phthisis, a wasting).

Evidences of Intra-Abdominal Tuberculosis

The clinical picture of tuberculosis of the mesenteric lymph nodes is variable and vague. Signs and symptoms are due in part to pressure effects on nerves, vessels and intestinal loops, produced by the enlarged glands. Pressures on veins produce, at times, slight edema of one or both ankles, visible engorgement of the superficial epigastric or superficial circumflex iliac vessels; even the hepatic vein may be partially obstructed, with a resulting tendency to a light jaundice; or the portal vein may be implicated by a node near the porta hepatis, yielding some degree of ascites and of visible stasis within the anterior abdominal wall veins of the portal collateral set. Pressures on afferent sensory nerves may account for the frequently complained-of sensation of abdominal fullness, or for a positive discomfort within the belly, made worse, perhaps, by walking or jarring. And the involvement of efferent motor nerves may initiate secretomotor irritative phenomena within the gastro-intestinal tract. Among these are, diarrhea, nausea, vomiting and dyspepsia. Pressures directly upon intestinal loops give rise, at times, to evidences of low-grade mechanical obstructions of the bowel; increasing constipation, flatulence, intermittent attacks of colicky pain. Normal functions of the involved nodes are interfered with, and loss of weight, loss of strength, loss of appetite, and loss of general health insidiously develop. Vague masses, consisting partly of the caseous or matted nodes and in part of adherent intestinal loops, may be palpable within the abdomen. These soft, pseudotumors, if present, are sometimes palpable rectally or vaginally as well as abdominally. Thomayer's sign is often present.[299] The spleen may be found slightly or moderately enlarged. An umbilical induration, as a chronic hydrocele, leads to a suspicion of a tuberculous peritonitis; unusual pigmentation of the skin or buccal mucous membrane suggests the presence of an associated adrenal involvement; a chronic non-specific urethral discharge may imply the presence of a concomitant tuberculous seminal vesiculitis.

A. J. S., n. s. Vol. X, No. 3, p. 626

To summarize: with any chronic, vague, abdominal complaints of insidious onset occurring in children or young adults, the possibility of an intra-abdominal tuberculous lymphadenitis or of a tuberculous peritonitis should be considered. The suspicion as to the presence of a tuberculous process is strengthened when there are evidences of mild venous blockage, of vasomotor gastrointestinal irritative phenomena, or of low-grade mechanical obstructions of the bowel. Soft pseudotumors or small amounts of free fluid, when also present, indicate the diagnosis. And when such findings occur in patients having a history of familial tuberculosis, or with a history or evidences of a tuberculous process at any other point within the body, the diagnosis becomes presumptive. The combination of a secondary anemia and a low-grade lymphocytosis is evidence of a confirmatory nature; and the added finding of a persistently rapid pulse, a slight daily temperature with regular diurnal variations, may be considered diagnostic.

Surgical Intervention for Tuberculous Peritonitis

There seems little question as to the efficacy of surgical intervention in selected cases of intra-abdominal tuberculosis. Removal of even a portion of the involved lymph glands has often been followed by a prompt and striking gain in weight and an alleviation or disappearance of the preoperative evidences of the disease. This has been explained as due to a turning of the tide in the combat between the invasive powers of the organism and the defensive powers of the host. Clinical cures following laparotomies for the drainage of tuberculous ascitic fluid are numerous and the causal relation of the operation in obtaining these cures has been presented as certain. Since the first report by König[300] of a cure following operation, surgical treatment for intra-abdominal tuberculous conditions (ileocecal tuberculosis; tuberculous peritonitis; tuberculous mesenteric lymphadenitis) has been placed upon a sound footing.[301, 302] While it is known that operations often fail to remove all tubercle bacilli or tuberculous lesions, it has been suggested that not only is the virulence-resistance balance frequently turned in favor of the patient, but that the

mere opening of the peritoneal cavity stimulates an outpouring of fresh serum and initiates a renewed local protective response.[303] Notwithstanding the value of surgery in selected

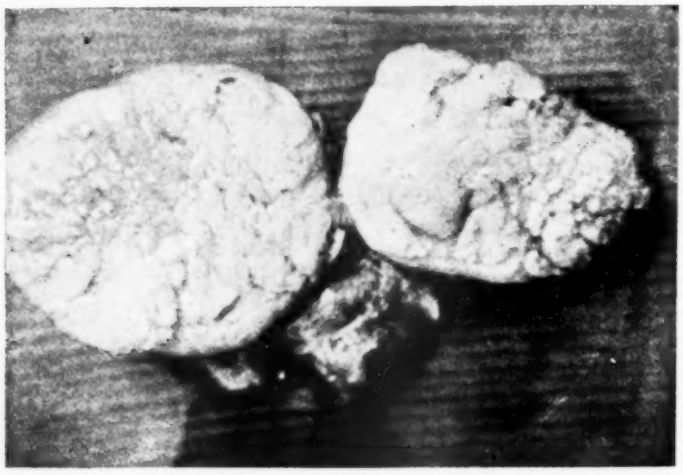
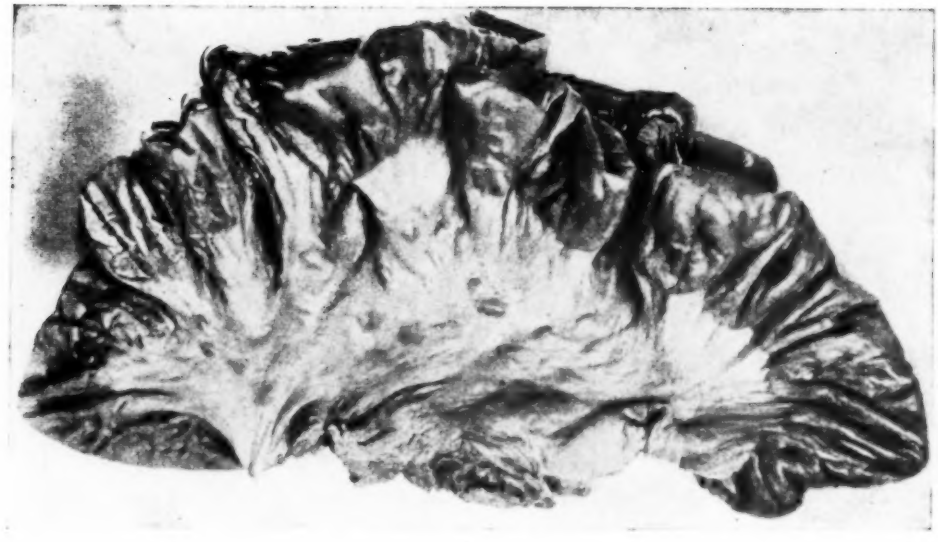


FIG. 202. Malignant lymphadenoma (Hodgkin's). Gland cut open to show the granular appearance produced by the increase in the fibrous tissue. Compare with tuberculous lymph glands in Figure 201. (From Edmunds.)

cases the basis for the treatment of tuberculosis within the abdomen, as elsewhere, is hygienic, dietetic, and heliotherapeutic care. Prolonged rest and medical supervision are essential for cases of surgical as well as for those of non-surgical tuberculosis.

Abdominal Symptoms Due to Primary Lymphadenopathies

Many of the signs and symptoms of tuberculous lymphadenitis may be caused by one of the essential lymphadenopathies. Vast leucemic nodes may give rise to a clinical picture which closely resembles that of tabes mesenterica. The additional presence, however, of enlarged superficial nodes throughout the body, of a large hard spleen, and of an unusually high lymphocytosis should leave little reason for errors. Leucemic glands tend to be general as to their intra-abdominal distribution[304] for the condition is a systemic disease and since the intestinal canal does not act as an atrium for infection, the mesenteric nodes do not tend to predominate. Lymphosarcoma has previously been discussed in pages dealing with intestinal



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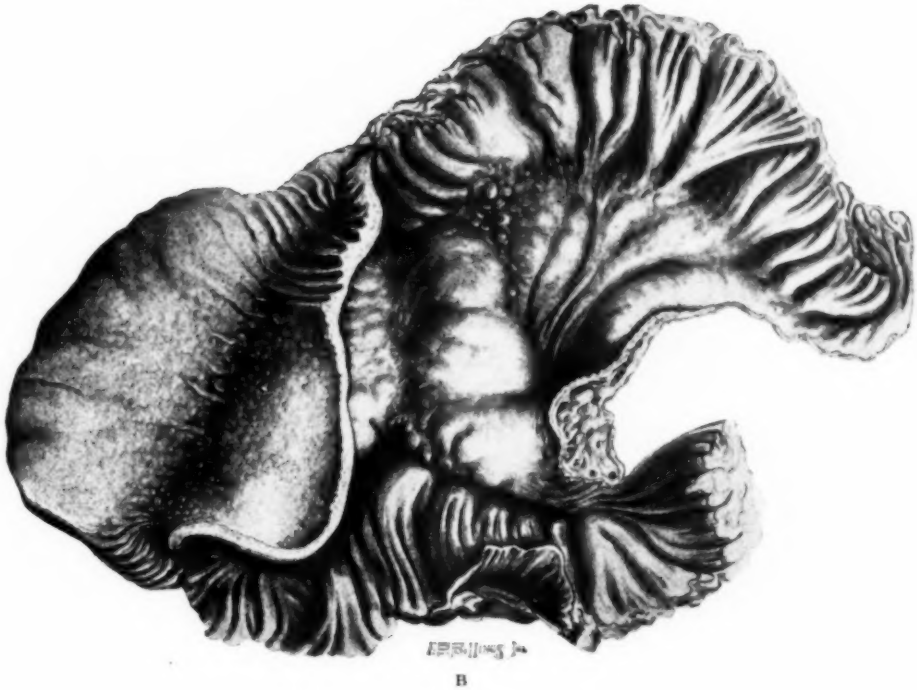

B

FIG. 203.

A. Enlarged mesenteric lymph nodes from a case of status lymphaticus in which death occurred during the administration of an anesthetic. The enlarged lymph glands are seen standing out within the mesentery. A large mass of lymph glands is present near the mesenteric root. (From Edmunds.)

B. Lymphocytoma of the ileum and mesenteric glands (leucemia). (From Osler and McCrae's Modern Medicine.)

FIG. 204.

Case of intestinal obstruction due to carcinoma of the cecum. Chronic dilatation of blood and lymph vessels of the mesentery and of the intestinal walls as here pictured is often the result of secondary malignant deposits in regional lymph nodes. Among evidences of enlargement of mesenteric lymph nodes from any cause are: signs and symptoms of chronic intestinal obstruction, gastrointestinal secreto-motor irritative phenomena, and chronic dilatation of superficial anterior abdominal-wall veins. (From Hertzler's The Peritoneum, Mosby.)

obstruction (p. 411) and with retroperitoneal tumors (p. 278). Hodgkin's disease may closely simulate tuberculosis of the abdominal nodes, for, contrary to usual textbook descriptions, Hodgkin's disease is not preeminently an affection of the cervical region; and as has been shown by Symmers[305] in a study of the distribution of enlarged nodes as found at autopsy, Hodgkin's disease more often effects first and with greatest intensity the mesenteric, retroperitoneal, and mediastinal lymph glands (Fig. 202). But with this form of malignant lymphoma there soon occurs extension to superficial lymph node groups; and the absence of a history of familial tuberculosis or of tuberculous lesions elsewhere in the body, the presence of the Pel-Ebstein rather than of the hectic type of temperature reaction, and the fact that locally the nodes do not caseate or become matted with Hodgkin's disease, all are important points in the differential diagnosis.[287] Primary malignant endotheliomata of the abdominal lymph nodes, both in a localized and a generalized form, have been reported[288] but the discovery of the endotheliomatous nature of the nodes, as is the case in identifying so-called pseudoleucemic tumors, must rest with the pathologist and in general because of the similarity of the essential lymphadenopathies to one another and to other intra-abdominal lymphatic affections, the surgeon is best fortified against the late discovery of diagnostic errors by making it a rule to submit to biopsy a specimen gland in every instance in which doubt remains in his mind as to the true cause of any lymphatic enlargement which he encounters.

QUESTIONNAIRE

1. What are the practical questions which should come to the surgeon's mind when he encounters enlarged intra-abdominal lymph nodes during the course of a laparotomy?
2. What are afferent lymph vessels? Efferent lymph vessels?
3. What characteristics should be especially noted about abnormal lymph nodes encountered during laparotomies?
4. Describe the general distribution of lymph nodes within the abdomen.
5. What are the major groups of intra-abdominal lymph nodes?
6. What are visceral lymph nodes? Retroperitoneal lymph nodes?
7. Describe the mesenteric group of lymph nodes.

A. J. S., n. s. Vol. X, No. 3, p. 631

8. Describe the lumbar lymph nodes. What are the areas drained by these nodes? In what way do lumbar nodes drain into the cisterna chyli?
9. Describe the celiac lymph nodes. What is their drainage area? In what manner do the celiac nodes drain into the cisterna chyli?
10. State in a general way the method by which the lymph vessels and lymph nodes associated with specific abdominal organs may be described.
11. What are the 5 most common lymphatic diseases of intra-abdominal lymph nodes?
12. What is meant by "sentinel" lymph nodes?
13. What is the location of the cystic node, the appendicular node, the right gastric node?
14. Where are the so-called Troisier nodes located? State their significance in abdominal disorders.
15. How do lymph nodes become secondarily involved from intra-abdominal malignancies?
16. What is meant by lymph permeation?
17. Describe proved routes of extension through lymph permeation from cancer of the breast.
18. Describe extension of lymph permeation into the abdominal cavity from an extra-abdominal malignancy; state the specific lymphatic pathways.
19. What is a malignant embolus?
20. Describe various ways by which primary malignancies within the abdomen may spread to remote regions within the body.
21. Explain blood stream invasion by malignant emboli which have traversed the thoracic duct.
22. How may the surgeon know exactly what lymph nodes and vessels are likely to be first involved by extensions from a primary malignancy of any specific organ?
23. Name two factors which indicate the necessity for wide excision of tissue about malignant growths.
24. Do all lymph vessels draining a primary malignant neoplasm pass to the lymph nodes situated nearest the growth?
25. What is meant by aberrant malignant implantations?
26. What lymph nodes should be removed during the excision of an ileocecal carcinoma? What large vessels require ligation in this operation?
27. Describe in general terms the factors which have been taken into consideration in regard to accepted radical operations for the removal of gastrointestinal malignant neoplasms.
28. What is meant by the statement "the surgery of gastrointestinal malignancies is the surgery of the gastrointestinal lymphatic system"?
29. What is the most common site for malignant growths in the male?
30. Describe the gastric lymph nodes.
31. What is meant by primary gastric nodes; secondary gastric nodes?
32. What is the relation, as to location, between gastric lymph nodes and gastric arteries?
33. Draw a diagram of the stomach and place upon this diagram the following lymph nodes or lymph node groups: the anterior left gastric glands; right suprapancreatic glands; lower biliary lymph glands; posterior left gastric lymph glands; the right and left paracardial lymph glands; the splenic nodes; left suprapancreatic nodes; subpyloric nodes; right and left gastroepiploic nodes.
34. Is glandular metastasis an early or a late occurrence with gastric carcinoma?
35. Give grounds for and explain answer.
36. Is secondary lymph glandular involvement with gastric carcinoma more common along the lesser or greater curvature?

A. J. S., n. s. Vol. X, No. 2, p. 632

37. Does or does not the presence of enlargement of gastric lymph nodes with gastric carcinoma mean that malignant metastasis has occurred?
38. Is the presence of enlarged nodes in connection with cancer a reliable index to be taken into consideration in determining the operability or non-operability of the growth?
39. At what points should the left gastric artery be ligated during a resection for gastric carcinoma?
40. When the splenic lymph nodes are enlarged with a gastric malignancy is the case operable or inoperable?
41. Does extention to lymph nodes about the celiac axis or superior mesenteric artery render a gastric carcinoma inoperable?
42. What is tabes mesenterica?
43. What is the meaning of the word tabes?
44. What is the location and nature of the pathological process with tabes mesenterica, with tabes dorsalis?
45. What is the most common site for an intra-abdominal tuberculous lymphadenopathy?
46. What is the usual gross appearance of abdominal tuberculous lymph glands?
47. What are common sites of tuberculous involvement found to be associated with tuberculous abdominal lymph glands?
48. What are some of the causes of wasting or emaciation with tuberculosis?
49. Describe in a general way the mechanisms by which symptoms are produced with tuberculosis of intra-abdominal lymph glands.
50. Describe some of the evidences of venous obstruction with intra-abdominal tuberculosis.
51. What is Thomayer's sign?
52. Explain the so-called pseudotumors sometimes observed with intra-abdominal tuberculosis.
53. Discuss methods for arriving at a diagnosis of tuberculosis of intra-abdominal lymph nodes.
54. Discuss surgical treatment for intra-abdominal tuberculous processes.
55. Give possible explanations for surgical cures obtained from operations for intra-abdominal tuberculosis in which not all tubercle bacilli or tuberculous lesions have been removed.
56. Discuss postoperative treatment for tuberculosis patients.
57. What is meant by primary or essential lymphadenopathies?
58. Discuss leucemia with special reference to the involvement of intra-abdominal lymph nodes.
59. Discuss abdominal lymphosarcoma.
60. Discuss the distribution of involved lymph glands in Hodgkin's disease.
61. Discuss the diagnosis of primary malignant endothelioma of the abdominal lymph nodes; of intra-abdominal pseudoleucemic tumors.
62. When is it advisable to submit abdominal lymph nodes to biopsy?

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AUTHOR'S NOTE

With the completion of this chapter dealing with Abdominal Lymphatics the serial publication of "A Clinical Study of the Abdominal Cavity and Peritoneum" comes to an end. The material covered in the issues of THE AMERICAN JOURNAL OF SURGERY from January to December 1930 constitutes, with the addition of a chapter on Visceral Neurology and certain practical diagnostic charts, the first volume of this postgraduate review.

This volume covers the following headings: A, The Empty Cavity and B, The Gastrointestinal Tract. There remain for consideration in a subsequent and companion volume: C, The Solid Organs, and D, The Peritoneal Membrane.

EPONYMIC STUDIES: DUCTS OF THE PANCREAS

1. Wirsung, Johann Georg (–1643). A German anatomist in Padua.
2. Santorini, Giovanni Domenico (1681–1737). (L. Jo. Dominici.) An Italian anatomist in Venice.
3. Vater, Abraham (1684–1751). A German anatomist at Wittenberg.

JOHANN GEORG WIRSUNG (vēr'soong)

Eponym: The main pancreatic duct, draining the entire length of the pancreas and joining the common bile duct to empty into the duodenum.

Nativity; Birth; Death: Bavaria. Town and date of birth unrecorded. Death, 1643.

Source of Eponym: Figura ductus cijusdam cum multiplicibus suis ramulis voviter in pancreate in diversis corporibus humani observatis: Padua, 1643. (In folio.)

Wirsung's original observations are recorded on a single rare copper plate. (Garrison's History of Medicine. Ed. 4, Saunders, 1929, p. 250.)

Discussion of Eponym: An interesting legend concerning Wirsung's discovery and the supposed relation of this to his death is related in the following brief biographical sketch (Sir M. Foster's Lectures on the History of Physiology during the Sixteenth, Seventeenth, and Eighteenth Centuries published in 1901 by the Cambridge University Press, as one of the Cambridge Natural Science Manuals).

"The first step was taken by John George Wirsung, who though a Bavarian by birth, held in the middle of the seventeenth century the once so famous chair of Anatomy at Padua. In a better to Riolan dated 1643, he described the duct of the pancreas which he had discovered the year before. He speaks of its entrance into the duodenum close to the mouth of the biliary duct, and of its ramifications in the body of the pancreas. He says that he found it easy to pass a style through from the body of the gland into the duodenum, but difficult to pass the style from the duodenum into the duct, that the duct is present in man at all ages, that he found it in all the animals which he had examined, and that it could not be either an artery or a vein, since it never contained blood, but on the contrary was often filled with a nearly colourless liquid which like bile stained a silver style.

"Wirsung's pupil John Maurice Hofmann claimed the discovery as his own, as one made by himself and laid hold of by his master; but there is no satisfactory evidence of this. Wirsung met with a tragic death [same year], being shot as he was entering his house at night; the legend states that a quarrel about the discovery of the duct was the cause of the murder, but it seems to have been the result of some private grudge." (p. 104.)

TRANSLATION OF SANTORINI'S "TABLE XII"

The duodenum, in which the most important factors [shown] are the liver, the gallbladder, the outlet, site, form, and number of the pancreatic ducts, and the disposition of the principal folds or rugae.

A. Lowest part of stomach excised from remainder, and at the same time dissected lengthwise with the pylorus and the duodenum, and spread out . . .

D. Part of the hepatic duct cut in two and stretched out, in which is found (b) a single mouth from branches which converge from the liver into this duct.

E. Part of the gallbladder is at the near end of the cervix, very flexuous, after the main bend of which at length it is led into (cc) a twin slender duct with numerous but short windings. This duct (d) terminates at a narrow opening in the hepatic canal; and then this canal.

The Property of the New York Hospital.

OBSERVATIONES ANATOMICÆ

JO: DOMINICI SANTORINI.

Supremi MAGISTRATUS ſalutis Venet. Protomedici, & in Veneto LYCEO Anatomes Profeſſoris,

PETRO I. MAGNO IMPERATORI,

Totiuſque Magnæ, Parvæ, & Albæ Ruſciæ AUTOCRATORI, Magno DUCI Moſchoviæ, Chioviæ, Uladimiriæ, Novogradiæ, CZARO Caſani, &c.

D. D. D.

N° 354

PROPERTY OF THE N. YORK HOSPITAL.
New York
4364

LUGDUNI BATAVORUM,

Apud GYSBERTUM LANGERAK, 1739.

FIG. 205A. Title page of Santorini's "Observationes Anatomicae."

JO: DOMINICI SANTORINI

ANATOMICI SUMMI

SEPTEMDECIM TABULAE

QUAS

NUNC PRIMUM EDIT ATQUE EXPLICAT

IISQUE ALIAS ADDIT

DE STRUCTURA MAMMARUM

ET

DE TUNICA TESTIS VAGINALI

MICHAEL GIRARDI

IN REGIA PARMENSI UNIVERSITATE ANATOMES
PROFESSOR PRIMARIUS
ET CAESAR. LEOPOLD. CAROL. ACAD.
NATUR. CURIOS. SOCIUS.

S L
Boston Med Library

LB
99046

PARMAE

EX REGIA TYPOGRAPHIA

CIↃ. IↃCC. LXXV.

FIG. 205B. "Seventeen tables of anatomy," by Jo. Domenicus Santorini, now edited and explained for the first time and to which are added "The structure of the breasts" and "The tunica testis vaginalis" by Michael Girard, head professor of anatomy in the Royal University of Parma, and fellow of the Emperor Leopold Charles Academy of Natural Curiosities. Parma: The Royal Press, 1775.

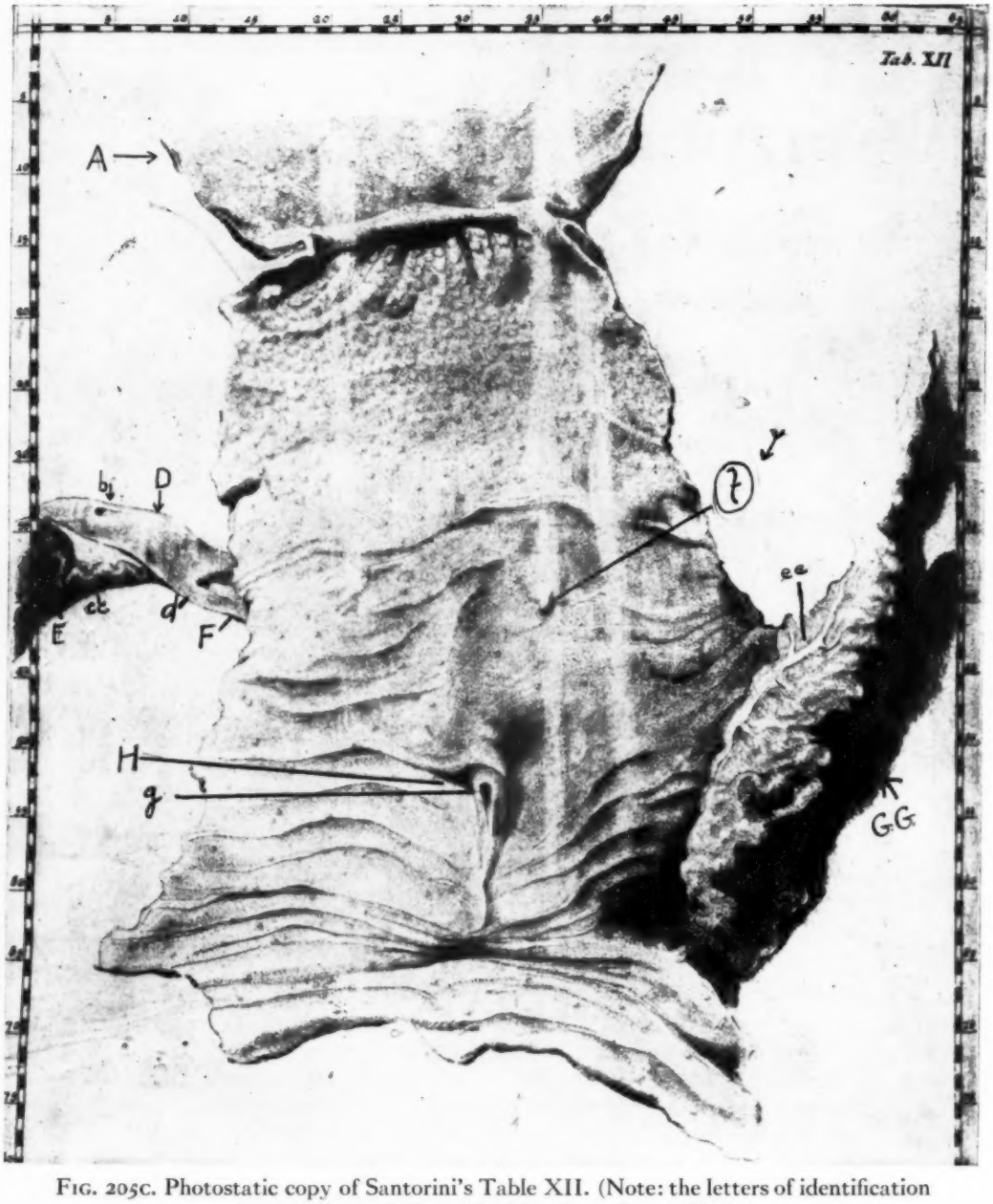

FIG. 205c. Photostatic copy of Santorini's Table XII. (Note: the letters of identification are not those of the original but have been added.)

TABULA XII.

Inteſtini duodeni, in qua praecipue ſignificantur jecinoris, cyſtis fellae, ac pancreatis ductuum exitus, locus, forma, & numerus, ac rugarum principium, ac diſpoſitio.

A *Pars ima ventriculi ab reliquo exciſa, & in longitudinem una cum pyloro, ac duodeno diſſecta, & explicata;*

D *Pars ductus hepatici diſciſſa, & explicata, in qua eſt*

b *Oſculum unius ex ſurculis, qui a jecinore in hunc ductum corrivantur.*

E *Veſicae felleae pars eſt extrema cervici proxima, maxime flexuoſa, quae poſt flexum longe maximum in*

c c *Tenuem ductum crebris, ſed brevibus anfractibus geminatum producitur. Ductus hic*

d *Anguſto oſtio in porum hepaticum terminatur; atque tum porus is*

F *Ductus choledocus, ſeu communis, ex cyſtico videlicet, & hepatico conflatus dicitur, cujus confluxus ſimul ut plurimum cum ductu pancreatico uno, communique oſculo in duodenum eſt.*

G G *Pancreas, quoad per Tabulae anguſtiam licuit, exhibitum, cujus accuratior ſtructura, forma, & ſedes in* ſequenti *Tabula demonſtratur.*

e e Ductus pancreaticus,

• • • &c. Ejuſque rami.

f *Caruncula forma fere conica, in cujus extremo vertice tenue oſculum ſuperioris ductus pancreatici aperitur, per quod alias ſetam, ſtylum alias non difficulter immiſimus.*

H *Major caruncula, in cujus medio*

g *Conſpicuum oblongum oſculum eſt, quod ſingularis exitus eſt ductus communis a jecinore, & cyſti fellea venientis, ac majoris ductus etiam pancreatici. Haec autem caruncula latum pollicem fere longa in ſiniſtriore duodeni parte ſita, ſecundum longitudinem locata, leviſſime in arcum flexa, levem duodeni curvaturam ſequens, plurima ſui parte prominens, media inter inteſtini membranas procedens, tereti protuberantia, calamo ſcriptorio fere aequali, ſuis in ſedibus ſpeciem quamdam cylindri leniter curvati refert:*

FIG. 205D.

A. J. S., n. s. Vol. X, No. 3, p. 641

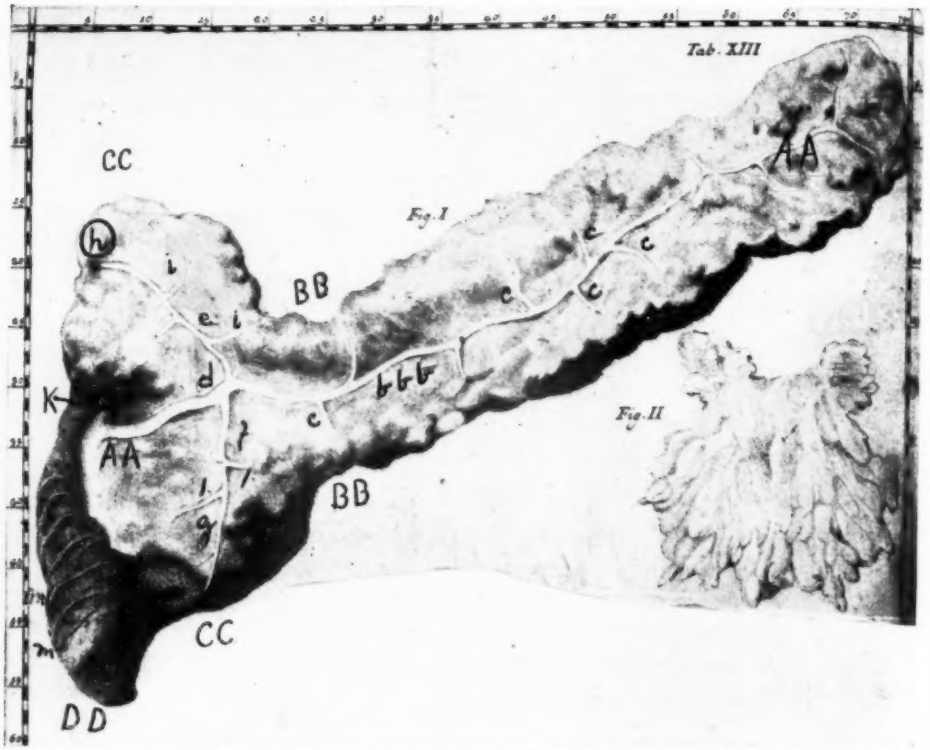

FIG. 205E. Photostatic copy of Santorini's Table XIII. (Note: the identifying letters did not appear on the original plate as here shown but have been added.)

TABULA XIII.

FIGURA I.

Exhibet pancreatis naturalem magnitudinem, formam, habitum, & obliquum positum, quemadmodum fere suis in sedibus constituitur, atque in longitudinem ita secti, ac deducti, ut omnis ductus ejus, exitusque in conspectum veniat, itemque portiunculam intestini duodeni pancreati adnexam, ac in longitudinem dissectam, & revolutam.

AA *Pancreatis longitudo omnis, atque latitudo.*

BB *Pancreatis pars tenuior, angustiorque, cervix a me nuncupata, subter quam pars plurima arteriarum, venarum, nervorum, ac lymphae ductuum ad mesenterium pertinentium fertur, eaque Tab. n.° indicatur.*

CC *Pars altera ipsius pancreatis dexterior in latitudinem ducta, quae in gibbum composita, intestino duodeno adnectitur, cujus tanta transversae accessionis amplitudo nulla hactenus in Tabula descripta fuit.*

aa *Extremae radiculae sunt.*

bbb *Ductus, qui per medium pancreas flexuoso tractu ab uno ad alterum extremum ad intestinum usque duodenum obliqueque defertur.*

ccc&c *Complures utrinque ramusculi, qui in medium hunc ductum confluunt.*

d *Longior, & plenior utringue alter ductus, qui in ductum medium pariter corrivatur:*

e *Superior nempe, &*

f *Inferior: ex gemino, inferiore scilicet, & superiore ductus unus tranfversus pene conflatur. cujus*

g *Principium in ima transversa pancreatis accessione est.*

h *Terminus autem, exitusque, qui in intestinum duodenum per caruncutam Tab. XII. lit. f descriptam secretum humorem invehit.*

iii&c. *Propagines majusculae ramorum, quae ab lateribus in utrumque hunc tranfversum ductum concurrunt, quae ab tranfversa pancreatis accessione radiculas trahunt.*

FIG. 205F.

Quamquam Graafius, (a) qui accuratius caeteris Spartam hanc excoluiſſe videtur, duplicis pancreatis ductus indicium praebuerit, & poſt ipſum Winslowus (b), aliique, ac in iis potiſſimum Summus Hallerus (c) propriis quibuſdam characteribus hunc ductum ornaverint; nihilo tamen ſecius Santorinus hac Tabula, dum cum pancreatico ductu alterum tranſverſum exhibet, niſi inventione, elegantia certe, atque ſedulitate deceſſoribus palmam praeripuiſſe videtur. Dum enim Graafius, ut caeteros brevitatis gratia praeteream, duplicem pancreatis ductum (quorum alterum interdum ut a majori prorſus ſejunctum, ita & penitus defuiſſe obſervavi) ſcriptis indicat, in Tabula tamen I., quam ipſe exhibet, ne indicium quidem alterius hujuſce ductus aut delineatione, aut verbis oſtendit: immo cum poſtremum furculum ductus pancreatici, qui huic Santorini tranſverſo ductui reſpondet, ac reliquos pancreatis furculos lit. B deſignaverit, illum non pro peculiari ductu, ſed cum reliquis furculis communem habuiſſe, apertiſſime evincitur. *Hic vero pancreatis alter ductus, cum in tranſverſum pene poſitus ſit, ejuſque tenuis origo ab imis latioris tranſverſae acceſſionis partibus procedat, complurium ramuſculorum confluxu auctus, ad eum ductum, qui ſecundum longitudinem eſt, ſeſe conſert, atque in illum influit: protinus autem ex adverſo ipſius latere eadem prope latitudine emergit, ac in ſuperiora ſeſe proripiens, in itinere furculorum acceſſione auctus, poſt levem curvaturam, latis circiter duobus digitis ſupra longioris ductus ingreſſum, duodenum inteſtinum ſubit. Id hujus ductus iter, ac inceſſus eſt: de quo tamen non ita intelligo quaſi humor ab imo delatus in tranſverſum per eum, qui ſecundum longitudinem defluit, in ſuperiorem partem contendere debeat; ſed ita accipi volo, quaſi unus tranſverſus ductus eſſet, tametſi (quod rationi maxime congruit) humor ab inferiori delatus in longitudinem, qui vero per longiorem delabitur, partim recta, partim in tranſverſum per hunc minorem ductum procedat. Forma autem, colore, tenuitate, humore alteri prorſus ſimilis: brevior*

(a) Regneri de Graaf. Opera omnia. *Lugduni an. 1678.* De Succo pancreatico *Cap. 1.*
(b) Traité du bas-ventre *n. 324.*
(c) Elem. Phyſ. *Lib. XXII. §. VI.*

tamen eſt, & anguſtior; etſi aliquando ampliſſimum ipſius exitum viderim. Ut ductum hunc conſtantiſſime comperi, ita frequentiſſime in longiorem influentem, aut, ſi iubet, efflucntem dicere adverti, ut alterutro inflato, ſicuti etiam habet Graafius, uterque ſtatim attollatur.

k *Ductus choledocus, ſeu communis, qui circumfuſus pancreatis natura ſui loci deſecta, quo illi in conſpectum venit cum extremo majoris ductus pancreatis corrivatur, quocum pariter per majorem, inferioremque carunculam Tab. XII. lit.* H *in duodenum terminatur.*

DD *Portio inteſtini duodeni, quod propter pancreatis oram ſecundum longitudinem inciſum, atque inverſum,*

mm *Valvulas, ſeu rugas, &*

••• &c. *Glandulas profert.*

FIG. 205F. (*Continued*)

F is called the bile duct, or common duct, said to be inflated by the cystic and hepatic, whose union is such that it is one with the pancreatic duct and common opening in the duodenum, for the most part.

GG. Pancreas—shown as far as the limits of the table permit—, whose more accurate structure, form, and site are shown in the following tables.

(ee) Pancreatic duct and its branches.

(f) A caruncula almost conic in form, in whose extreme slender vertex is seen the upper outlet of the pancreatic duct, through which we insert sometimes a hair (seton), sometimes a stylus (probe) without difficulty.

H. Major caruncula, in the middle of which (g) is a conspicuous oblong opening, which is the sole outlet of the common bile duct coming from the liver, and from the gallbladder, and major ducts of the pancreas, too. Moreover, this caruncula, almost the width of the thumb in length, in the more left part of the duodenum, located longitudinally, slightly flexed in an arc, following the slight curvature of the duodenum, very prominent on its own part, proceeding half between the membranes of the intestine, with a rounded protuberance, almost like a reed pen for writing, bears in its locations a certain resemblance to a slightly curved cylinder.

TRANSLATION OF SANTORINI'S TABLE XIII

FIGURE 1

This shows the natural size, the form, the appearance, and the oblique position of the pancreas, how it is constituted almost in its own locations, both cut lengthwise and stretched out, so that its whole duct and outlet are visible; and it likewise shows the part of the duodenum which is attached to the pancreas, both longitudinally dissected and turned back.

AA. The full length and breadth of the pancreas.

BB. The more slender and narrower part of the pancreas, which I have called the cervix (neck), under which are carried to the adjacent mesentery the majority of arteries, veins, nerves, and lymph ducts, indicated in the table.

CC. The other part of the same pancreas, carried more to the right in latitude, which, shaped like a hump, is attached to the duodenum, whose great width of transverse increase (approach) has not so far been described in a table.

(aa) These are the ends of the radicula.

(bbb) A duct which runs obliquely through the middle of the pancreas in a winding tract from one end to the other, as far as the duodenum.

(ccc and c) Several little branches on both sides, which branches converge in the middle of this duct.

(d) On both sides a longer and fuller duct, which is likewise conducted into the middle of the duct: (e) above, certainly, and (f) below: from the double duct (namely, the lower one), and from the upper duct one transverse one is nearly produced, whose (g) beginning is in the lowest transverse increase (approach) of the pancreas. (h) Moreover, the end and outlet, which carries a secret humour into the duodenum through the caruncula described under letter f of table XII.

(iii et cetera) Somewhat larger branches, which cross this transverse duct from the sides, which bear radiculae from the transverse increase (approach) of the pancreas.

DISSERTATIO ANATOMICA IV

QVA

NOVVM BILIS DIVERTICVLVM

CIRCA

ORIFICIVM DVCTVS CHOLODOCHI VT ET VALVVLOSAM COLLI VESICAE FELLEAE CONSTRVCTIONEM

AD DISCEPTANDVM PROPONIT

ATQVE

SINGVLARIS VTRIVSQVE STRVCTVRAE EXIMIAM VTILITATEM IN VIA BILIS DETERMINANDA

EXPONIT

PRAESES

ABRAHAMVS VATER

PHILOSOPH. ET MED. DOCT. HVJVSQVE PROF. PVBL. ORD. ANATOM. ET BOTAN. SVBSTITVTVS

RESPONDENTE

PAVLO GOTTLOB BERGER

ILEBVRG. MISN. MED. CVLT.

AD D. XXII. APRILIS ANNI MDCC XX.

WITTENBERGAE, LITERIS GERDESIANIS.

FIG 206. Title page of volume IV of Vater's "Rissertatio Anatomica."

A. J. S., n. s. Vol. X, No. 3, p. 645

EXPLANATION

Although de Graaf[a] who seems to have cultivated this Sparta more accurately than others, called attention to a sign of a double pancreatic duct, and after him Winslow,[b] and others, among them chiefly the great Haller,[c] endowed this duct with certain characteristics; nevertheless Santorini in this Table, while he shows another transverse duct with the pancreatic duct, does not seem to have excelled his predecessors unless in inventiveness, in neatness certainly, and in zeal. For while de Graaf, to omit the others for the sake of brevity, wrote about a double duct of the pancreas (one part of which I have sometimes observed as entirely separated from the larger part, or even lacking altogether) nevertheless in his own Table 1 he certainly gives no indication of this second duct either in the drawing or in the description: on the contrary since he designated by the letter B the hindmost branch of the pancreatic duct, which corresponds to this transverse duct of Santorini, as well as the rest of the small branches of the pancreas, it is very evident that he considered this not as a special duct but as common with the other small branches. Indeed this other duct of the pancreas, since it lies almost transversely and has its slender origin in the lowest parts of the wider transverse accessory ducts, enlarged by the confluence of numerous small branches, leads to that duct which lies longitudinally and enters it; however it straightway emerges from the opposite side at almost the same latitude, and running upward, enlarged on the way by the addition of branches, after a slight curve enters the duodenum about two fingerbreadths above the entrance of the longer duct. This is the route and the entrance of this duct: however, from this I do not think that the humor carried through it from below into the transverse part which flows into the second longitudinal duct, necessarily flows on into the upper part; nevertheless I consider this to be a single transverse duct, although (which is most logical) humor which indeed flows for a longer distance through the longer duct, flows partly straight, partly transversely through this smaller duct. Moreover in form, in color, in slenderness, and in humor both are entirely alike: however this is shorter and narrower; and yet sometimes its exit seems to be very wide. As I have discovered this duct very consistently, so very frequently in its longer influx or, if preferred, its efflux, I have noticed either one swollen, as de Graaf holds, or both raised up.

(k) The bile duct, or common duct, which proceeds surrounded by the cut off nature of the pancreas in its place, in which it comes into view with the end of the major pancreatic duct, equally through the major and lower caruncula designated by letter H in Table XII, terminates in the duodenum.

DD. A portion of the duodenum, which near the mouth of the pancreas, cut lengthwise, and inverted, (mm) has valvules, or wrinkles, and glandules.

GIOVANNI DOMENICO SANTORINI

Eponym: Duct of Santorini, accessory duct of pancreas, the smaller of the two ducts found in the interior of the pancreas.

Nativity: Venice, Italy.

Birth, Death: Born June 7, 1681. Died May 7, 1736.

Education: Early education received under Jesuit priests. Classical and early medical education received from Delphini. Later studies conducted in Pisa; there studied under Malpighi and Bellini.

Doctor's degree at Pisa, October 18, 1701. Later studied in Bologna and Padua.

[a]Regneri de Graaf. Collected Works. London, 1678. Pancreatic juice Chap. 1.

[b]Treatise on the Abdomen, n. 324.

[c]Elementary Physiology, Book XXI, §VI.

1702. Became connected with Department of Anatomy in the Physico-Medical College of Venice. **Connections:**

1706. Became Professor of Anatomy, a position which he held until 1728.

See photostat. **Source of Eponym:**

Observationes Anatomicae, Venice, 1724. Opucula Medicade de structura et motu fibrae; nutritione animali; hemorrhoidibus; et de catameniis, 4p. 1., 228 pp. 8, Rotterdami, J. D. Beman, 1719. **Other Writings:**

Istoria d'un eto estratto felicemente intero dalle parti deretane. 51 pp. 4. Venezia, G. Tommasini, 1727.

After studying under the Jesuit priests Santorini desired to enter the priesthood much against the wishes of his father, Pietro Santorini, a pharmacist. Through the intervention of a friend of the family it was arranged that the church refuse to accept Santorini. Santorini married and had one son (Pietro) who also became a physician and upon his father's death wrote his biography (Diarium; P. Oreschi). Among Santorini's friends were Morgagni, Bernardo, Zandrini and Bonis. **Points of Interest:**

Ref. Handbook Med. Sciences. Ed. 7, N.Y., Wood. 1923, 7: 635. **Special References:**

Biographie Universelle. Leipzig, Brockhaus, 1864. 37: 687.

Capparoni, Pietro. Profili Bio-Bibliografici di Medici E. Naturalisti celebri Italiani of the 15th to 18th century. Rome, 1925, p. 97.

Lack of space prevents the reproduction here of a photostatic copy of Vater's own description of the ampulla which bears his name and of the translation of the original Latin text. This may be found in Vater's "Qua Novum Bilis Diverticulum" (Dissertatio Anatomica t.3, p. 269).

ABRAHAM VATER

A dilatation at the point of junction of the pancreatic and the common bile ducts just before they enter into the duodenum. **Eponym:**

Wittenberg, Germany. **Nativity:**

Born 1684. Died 1757. **Birth, Death:**

Vater studied medicine at the universities of Meiseburg and Leipzig and graduated at the University of Wittenberg. He then traveled extensively in Germany, England and Holland and to this latter country he returned several times to study under the most famous anatomist, Professor Ruysch. **Education:**

1717. Made Professor of Medicine at the University of Wittenberg. **Connections:**

1719. Made Professor of Anatomy. 1737. Made Professor of Pathology at this same university.

1746. Made Professor of Therapeutics.

Qua Novum Bilis Diverticulum Circa Orificium Ductus Choledochi ut et Valvulosam Colli Vesicae Felleae Constructionen ad Disceptandum Proponit atque Singularis Utriusque Structurae Eximiam Utilitatem in via Bilis Determinanda Exponit. Paulo Gottlob Berger, Ileburg, 1720. **Source of Eponym:**

De Succi Nervei Secretione Mechanica. Wittenberg, 1711. **Other Writings:**

Ac Method Nova Transplantadi Variolas per Isitionem, 1710.

Catalogas Plantarum Imprinin Exoticarum Horti Adademici Vittenburgensis, 1721.

De Chirurgiae Antiquitate ac Dignitate et Collegionem Chirurgionrum Utilitate, 1724.

De Utilitate Observationis in Medicina, 1724.

De Uteru Gravida, Physiologiae et Pathologiae Considerato, 1725.

De Observationibus Rarissi Mus Calculorun in Corpore Humanum Generadionen Illustradibus, 1726.

De Efficacia Admiranda Chin-Chinae ad Gangraenam.

Sistendan in Anglia; De Olei Varum Efficacia Contra Morsum Canis Rabrosi Experimento Dresdae Facto Adstructa, 1736.

Museum Anatomicum Proprius Helmstadt, 1750.

Special References Michaud Biographic Universalle. Paris, 1854, Vol. 42.

Grand Dictionnaire Larousse.

Reference Handbook of Medical Sciences. N. Y., Wood, 1925, Vol. 8.

Points of Interest: Vater's father, Christian Vater, occupied the chair of Medicine at Wittenberg.

ACKNOWLEDGMENTS

At the completion of the serial publication of "A Clinical Study of the Abdominal Cavity and Peritoneum" and prior to its appearance in book form the author wishes to make several acknowledgments:

To Dr. George David Stewart, Professor of Surgery at New York University and Bellevue Medical College and to Dr. Arthur M. Wright, Director of the Third Surgical Division of Bellevue Hospital, for their kind cooperation and helpful criticisms; for access to the Third Division records; and in grateful recognition of the fact that it is the inspiration afforded by their surgical teachings and gained through working under their professional leadership which has made this book a possibility.

To the following medical libraries from which were obtained rare volumes used in the study of eponyms:

Library of the Surgeon General's Office, Washington, D. C.

Library of the New York Academy of Medicine, with special gratitude for the services of translators under the direction of Miss Helen Sayre.

Library of New York University and Bellevue Medical College, and to its librarian, Miss Helen R. Bayne.

Library of Cornell University Medical School.

To many authors and publishers, specifically to be listed in the book itself, for use of cuts and illustrations which have previously appeared elsewhere.

To Dr. Harold D. Senior, Professor of Anatomy of New York University and Bellevue Medical College, for valued conferences concerning anatomical details; and to Professor Horatio B. Williams of the Department of Physiology at the College of Physicians and Surgeons of New York (Columbia University) and to Dr. Samuel Standard (Department of Physiology of New York University) for aid regarding physiological data.

To Dr. Edward Milton Foote for both direct and indirect aid during the compilation of the material.

To the following, for services or advice in the preparation of individual chapters or of specific phases of the work: Dr. Joseph R. Bierman, Dr. William K. Livingston. Dr. Lewis Ellmore, Dr. Andre K. Brunner, Dr. Meyer J. Kutisker, Dr. Anthony S. Bogatko, Dr. A. A. Neuwirth, Mr. Ben Sandler, Mr. Ralph Levine, Mr. H. Blume. and Mr. Benjamin Schwartz.

To Frank Netter, for his carefully prepared teaching diagrams and illustrations, the excellence of many of which has been self-evident in foregoing pages. And to Prof. Morrison of the Department of Pathology of Bellevue Hospital, under the direction of Dr. Douglas Symmers, for the making of certain photographs.

To Gertrude B. Livingston, to whom this volume is dedicated; for her tireless energy, constant encouragement, and complete cooperation have made into a pleasant memory a task which might otherwise have been most difficult or quite impossible of accomplishment. She has been in the very strictest sense of the term full co-author of this book.

And finally, to Mr. Paul B. Hoeber, since upon his shoulders rests the responsibility for initiating this endeavor; and since his *carte blanche* as to the accumulation and preparation of material has proved a remarkable stimulus to effort. It would, indeed, be difficult to imagine what further cooperation an author might desire than has been most generously accorded by the publishers of this volume.

THIS MONTH'S CONTRIBUTORS

ALVAREZ, WALTER C., M.D., F.A.C.P., Rochester, Minn.
Assoc. Prof. of Med., Mayo Found. for Med. Educ. & Research, Graduate School, Univ. of Minn.; Assoc., Section, Div. of Med., Mayo Clinic.

ANDRESEN, ALBERT F. R., M.D., F.A.C.P., Bklyn., N. Y.
Clin. Prof. of Med. (Gastroenterol.), L. I. Coll. of Med.; Attend. Physic. (Gastroenterol.) L. I. Coll. Hosp.; Chief, Gastroenterol. Dept., Polhemus Mem. Clinic; Press., N. Y. Gastroenterol. Ass'n.; Sec'y, Sec. on Gastroenterol. & Proctol. A. M. A.

BESSESEN, DANIEL H., M.D., Minneapolis.

BOWER, JOHN O., M. D. F.A.C.S., Philadelphia.
Clin. Prof. Surg. Research, Temple Univ. School of Med.; Surg., Philadelphia Gen. Hosp.; Attend. Surg., U. S. Vet. Hosp., No. 59.

BROWN, SAMUEL, M.D., Cincinnati.
Direc., X-ray Dept., Jewish Hosp.; Roentgenol., Jewish and General Hosp.; Instruc., Roentgenol., Med. Coll. Univ. of Cincinnati.

BURNS, JOHN C., M.D., Philadelphia.
Staff, Dept. Surg. Research, Temple Univ. Med. School; Staff Member, Temple Univ. Hosp., Philadelphia Gen. Hosp.

CALDWELL, GUY A., M.D., F.A.C.S., Shreveport, La.
Visit. Surg.-in-Charge, Orthopedic Dept., Shreveport Charity Hosp.; Visit. Surg., Schumpert Mem., Highland, North Louisiana, and Tri-State Sanit.

CASE, JAMES T., M.D., F.A.C.S., Chicago.
Prof. Roentgenol., Northwestern Univ. Med. School; Surg., Battle Creek Sanit.; Roentgenol., Passavant Hosp.; Editor, Annals of Roentgenology.

CUTTING, R. A., M.D., PH.D., New Orleans.
Assist. Prof., Tulane Univ. School of Med.; Assist. Visit. Surg., Charity Hosp.

DECOURCY, JOSEPH L., M.D., Cincinnati.
Staff Surg., Good Samaritan Hosp.

DEVRIES, JOHN K., M.D., New York.
Assist. Urol., N. Y. Hosp.

DIOCLES, LOUIS, M.D., Paris, France.
Chief, Radiol. Dept., Med. Clin., Hôtel Dieu.

EMRICH, WM. H., M.D., Louisville.
Obstet. & Gynec., Emrich Hosp.

EWELL, GEORGE H., M.D., Madison, Wis.
Urol., & Surg. Pathol., Methodist Hosp.

GLASSER, S. THOMAS, M.D., C.M., New York.
Staff, Metropolitan Hosp.

GOLDMAN, BENJAMIN, M.D., Erie, Penna.
Lectur., "Surgical Nursing" Nurses Training School, Hamot Hosp.; Clin. Surg. Assist., Hamot Hosp.; Cons. Physic., Erie Infants Home & Hosp.; Attend. Physic., B'nai B'rith Home, Fairview.

HARRIS, ROBERT I., M.D., M.C., M.B.(Tor.), Toronto, Ont.
Sr. Demonstr. in Surg., Univ. of Toronto; Surg., Dept. of Pensions & Nat. Health, St. John's Hosp; Assoc. Surg., Toronto Gen. Hosp.

JACKSON, ARNOLD S., M.D., M.S., F.A.C.S., Madison.
Attend. Surg., Methodist Hosp.; Precep., Univ. of Wisconsin Med. School.

KIMBALL, FRANCIS N., M.D., New York.
Urol., N. Y. Hosp.

KLEINBERG, SAMUEL, M.D., F.A.C.S., New York.
Attend. Surg., Hosp. for Joint Diseases; Associate Surg., Hosp. for Ruptured & Crippled; Assoc., Dept. of Surg., Lebanon Hosp.; Attend. Orth. Surg., Israel Orphan Asylum; Chief, Orth. Serv., United Israel-Zion Hosp.; Bklyn.; Cons. Orth. Surg., N. Y. State Dept. of Labor, Rockaway Beach Hosp. and Israel Orphan Asylum.

LAROCHELLE, FRED D., M.D., Springfield, Mass.

LAU, FREDERICK T. M.D., F.A.C.S., New York.
Attend. Urol., N. Y. Hosp.; Attend Surg. & Direc. of Urol., Grasslands Hosp., Valhalla; Cons. Urol., White Plains Hosp., White Plains, Matteawan State Hosp., Beacon; Chief of Female Urol., N. Y. Hosp.

LIVINGSTON, EDWARD M., M.D., New York.
Instruc. of Surg., N. Y. Univ. & Bellevue Med. Coll.; Assist. Visit. Surg., Bellevue Hosp.

MATTHEWS, HARVEY B., M.D., F.A.C.S., Bklyn., N. Y.
Assoc. Prof. Obstet. & Gynec., L. I. Coll. Hosp.; Assoc. Attend. Obstet., Methodist Episcopal Hosp.

MARTINON, ANTONIO RAMOS, M.D., Havana, Cuba.

MENGLE, HAROLD A. K., M.D., Philadelphia.
Dept. Surg. Research, Temple Univ. Med. School; Staff Member, Temple Univ. & Philadelphia Gen. Hosp.

MOODIE, ROY L., M.D., Santa Monica, Calif.
Paleopathol., The Wellcome Historical Med. Museum, London.

PEARSE, HERMAN E., JR., M.D., Rochester, N. Y.
Assist. Prof. of Surg., Univ. of Rochester School of Med. & Dent.; Attend. Surg., Strong Memorial & Rochester Municipal Hosp.

PETERS, JOHN P., M.D., New Haven.
Prof. Int. Med., Yale Univ. School of Med.

REINECKE, HAROLD G., M.D., Cincinnati.
Assist. Prof. Roentgenol., Univ. of Cincinnati Med. Coll.; Direc., X-ray Dept., Cincinnati Gen. Hosp.

SAUER, PAUL KURT, M.D., PH.G., F.A.C.S., New York.
Instruc. in Surg., Cornell Univ. Med. Coll.; Assoc. Surg., Lenox Hill Hosp.; Chief, Surg. Clin., Out-Patient Dept., Lenox Hill Hosp.

UPDEGRAFF, HOWARD L., M.D., Hollywood, Calif.
Chief, Plastic & Reconstruc. Surg. Staff, Cedars of Lebanon Hosp.

WARD, GRANT E., M.D., F.A.C.S., Baltimore.
Assist. Clin. Surg., Johns Hopkins Med. School; Assist. Disp. Surg., Johns Hopkins Hosp.

SUBJECT INDEX TO VOLUME X

(B.B.) = Bookshelf Browsing. (Bi.B.) = Biographical Brevities. (B.R.) = Book Review. (E.) = Editorial.

Abdominal wall, fistulae of, 493
Adenocystoma, malignant papillary, of right ovary, with metastasis to cervix, 352
Alcohol injection of nerve roots for thrombo-angiitis obliterans, 107
Allergy following rectal administration of quinine—alcohol—ether in labor, 53
American Journal of Surgery's Contribution to Radiology in 1930 (E.), 583
Anastomosis, bilateral uretero—sigmoid, by Coffey method, 245
gastro-intestinal, closed aseptic and quick method of, 35
Anatomy, handbook of (B.R.), 384
Anemia, marked secondary, prolapse of gastric polyp into duodenum with, 355
Anesthesia for cardiac and asthenic patient, 469
combination, with sodium isoamyl ethyl barbiturate as basal agent, 300
regional, as applied to urological surgery, 325
Anus and rectum, benign lesions of, 255
carcinoma of, 547
Aphasia in children (B.R.), 383
Apparatus, pneumothorax, one-man, 140
Appendicitis, chronic, ulcer, peptic, and, differential diagnosis of, 274
Appendix, diverticula of, 564
Arthritis, chronic, of the spine, manipulative treatment of, 285
Arthrodesis, operative, of the spine, 341
Asthenic, and, cardiac patient, anesthesia for, 469
Attachment improved foot support, for Thomas Splint, 562
Avulsion, traumatic, of tibial tubercle, 577

Bacilluria, tuberculous, observations on the pathology of surgical tuberculosis with particular reference to incidence of, 514
Bandaging, minor surgery and (B.R.), 384
Barbiturate sodium isoamyl ethyl as basal agent, combination anesthesia with, 300
Benign lesions of anus and rectum, 255
papilloma of renal pelvis, 576
tumors of hepatic flexure, 573
Bilateral uretero-sigmoid anastomosis by Coffey method, 245
Bladder tumor pathology, clinical application of, 67
urinary, consideration of surgical procedures in treatment of malignant disease of, 69
Bloodless modification of Porro-Cesarean section, 299
Bodies, foreign, localization and extraction of (E.), 159
Bone sarcoma, *x*-ray diagnosis of, by mail (E.), 157
Bowel, the, how waves go down, 444
Breasts, pendulous, correction of, 80
Burns (B.R.), 166

Calcification, chemistry and physiology of, 530
Calcium fixation, some observations in, 294
Calculi, giant bilateral ureteral, 362
Campiodol, emulsified—a new urographic medium, 320
Carcinoma of anus and rectum, 547
of cervix uteri with special reference to its occurrence in early life, 150
Carcinomatous degenerations of cervical polyp, 136
Cardiac and asthenic patient, anesthesia for, 469
Cervix (ces), lacerated post-partum, in primipara, technic of routine primary repair of, 557
metastasis to, malignant papillary adenocystoma of right ovary, with, 352
uteri, carcinoma of, with special reference to its occurrence in early life, 150
Chemistry and physiology of calcification, 530
Children, aphasia in (B.R.), 383
urology in, 358
Chirurgie, die (B.R.), 166
die (B.R.), 382
Chronic nasal sinusites and its relation to general medicine (B.R.), 166
Clinical application of bladder tumor pathology, 67
study of abdominal cavity and peritoneum, 167, 385, 597
Clio Medica (B.R.), 590
Closed aseptic and quick method of gastrointestinal anatomosis, 35
Club-foot, congenital (B.R.), 166
Coffey method, bilateral uretero—sigmoid anastomosis by, 245
Colon, diverticulitis of, 63
Colonic therapy, 496
Combination anesthesia with sodium isoamyl ethyl barbiturate as basal agent, 300
Complete accidental cutting of ureter during laparotomy with non-surgical anastomosis, 571
Complications following use of gold spring pessary, 143
Congenital club-foot (B.R.), 166
Consideration of surgical procedures in treatment of malignant disease of urinary bladder, 69
Contusions, fractures, lacerations and their relation to disability, 56
Correction of pendulous breasts, 80
Cysts, bilateral ovarian, pregnancy with, 338

Danger of prolonged use of Lugol's solution in treatment of exophthalmic goiter, 475
Diabetes mellitus, pathology of (B.R.), 383
Diagnosis, differential, of peptic ulcer and chronic appendicitis, 274
and treatment of tuberculosis of genital tract, 84
x-ray, of bone sarcoma by mail (E.), 157
Diaphragm, roentgen significance of gas under, 93
Diathermy, electro-surgery and, status of, in treatment of diseases of genitourinary tract, 116
Dictionary, practical medical (B.R.), 382
Diet after operations on the stomach, 448
Differential diagnosis of peptic ulcer and chronic appendicitis, 274
Disability, relation of, to fractures, contusions, lacerations, 56
Diseases of digestive system, practical treatise on (B.R.), 593
of genitourinary tract, treatment of, present status of electrosurgery and diathermy in, 116
malignant, treatment of, of urinary bladder, consideration of surgical procedures in, 69
of the skin (B.R.), 382
Dislocation, congenital, of the hip, early treatment of, at the Istituto Ortopedico Rizzoli (E.), 369
Diverticulitis of colon, 63
Diverticula of the appendix, 564

Duodenum, prolapse of gastric polyp into, with marked secondary anemia, 355

Early treatment of congenital dislocation of hip at the Istituto Ortopedico Rizzoli (E.), 369
Electrosurgery and diathermy, present status of, in treatment of diseases of genitourinary tract, 116
as a hemostatic instrument in operations upon liver, kidney and spleen, 540
Elementary zoology for medical students (B.R.), 384
Emergency surgery (B.R.), 591
Empyema, chronic, surgical treatment of, 472
Encyclopaedia Britannica (B.R.), 164
Enterostomy, primary, perforated typhoid ulcer closed by, 149
Eventration, postoperative, 78
Exteriorization and utilization of sac and redundant peritoneum in radical treatment of inguinal hernia, 130
Extraction, localization and, of foreign bodies (E.), 159

Fiftieth jubilee of the social and scientific activity of the Emeritus Professor of Surgery, V. I. Razumovsky (B.B.), 378
Fistulae of the abdominal wall, 493
Foramen of Morgagni (Bi.B.), 161
Forceps, skin clip, 350
Fracastorii, Hieronymi (B.R.), 594
Fractures, contusions, lacerations and their relation to disability, 56

Gas, roentgen significance of, under the diaphragm, 93
Genital tract, tuberculosis of, diagnosis and treatment of, 84
Genitourinary tract, treatment of diseases of, present status of electrosurgery and diathermy in, 116
Giant bilateral ureteral calculi, 362
Goiter, exophthalmic, danger of prolonged use of Lugol's solution in treatment of, 475
surgical, 482
Graft, ovarian, in the uterus, 305
Gynecology, operative (B.R.), 594
text-book of (B.R.), 592

Handbook of anatomy (B.R.), 384
Hemangiomata of intestine, 241
Hematocele, infected pelvis, containing fetal bony elements, 581
Hemihypertrophy, progressive facial, reconstructive surgery in, 439
Hemorrhoids, 344
Hemostatic instrument, electrosurgery as, in operations upon liver, kidney and spleen, 540
Hepatic flexure, benign tumors of, 573
Hernia, inguinal, exteriorization and utilization of sac and redundant peritoneum in radical treatment of, 130
Hickey, Preston M. (E.), 585
Hip, early treatment of congenital dislocation of, at Istituto Ortopedico Rizzoli (E.), 369
Histology for medical students (B.R.), 383
Historic artificial limbs (B.R.), 591
Holder, skin clamp, 142
How waves go down the bowel, 444
Hypernephroma, papilloma and stone occurring in horse-shoe kidney, 487

Improved foot support attachment for Thomas splints, 562
Infected pelvic hematocele containing fetal bony elements, 581
Injection, alcohol, of nerve roots for thrombo-angiitis obliterans, 107
treatment of varicose veins, 19
Instrument, hemostatic, electrosurgery as, inoperations upon liver, kidney and spleen, 540
Interpretation of double ureters, 122
Intestinal toxemia (B.R.), 593
Intestine, hemangiomata, 241

Kidney, horse-shoe, hypernephroma, papilloma and stone occurring in, 487
Koher, George Martin, reminiscences of (B.R.), 383

Labor, allergy following rectal administration of quinine-alcohol-ether, in, 53
Laboratory medicine (B.R.), 609
Lacerations, fractures, contusions, and their relation to disability, 56
Laparotomy with non-surgical anastomosis, complete accidental cutting of ureter during, 571
Lead poisoning and the eighteenth amendment, 32
Leaders, medical (B.R.), 382
Lehrbuch der chirurgie (B.R.), 595
Lesions, benign, of anus and rectum, 255
Limbs, historic artificial (B.R.), 591
Localization and extraction of foreign bodies (E.), 159
Lugol's solution, danger of prolonged use of, in treatment of exophthalmic goiter, 475

Malignant papillary adenocystoma of right ovary with metastasis to cervix, 352
Manipulative treatment of chronic arthritis of the spine, 285
Mediastinum, superior and posterior, roentgenological study of, 452
Medical leaders (B.R.), 382
students histology for (B.R.), 383
Medicine, general, chronic nasal sinusites and its relation to (B.R.), 166
laboratory (B.R.), 592
Method, Coffey, bilateral uretero—sigmoid anastomosis, 245
Mommsen's, of submaximal stimulation for tibial pseudoarthrosis, 366
new, of blood vessel visualization (arteriography; veinography; angiography) in vivo, 225
Midwifery, practical, for nurses (B.R.), 594
Minor surgery and bandaging (B.R.), 384
Mommsen's method of submaximal stimulation for tibial pseudoarthrosis, 366
Morgagni, foramen of (Bi.B.), 161
Murphy button (Bi.B.), 377

Nerve roots, alcohol injection of, for thrombo—angiitis obliterans, 107
Nervous system, sympathetic, surgery of, 8
New method of blood vessel visualization (arteriography; veinography; angiography) in vivo, 225
surgical tourniquet, 349
urographic medium: emulsified campiodol, 320

Observations on pathology of surgical tuberculosis with particular reference to incidence of tuberculous bacilluria, 514
Obstetrics (B.R.), 384
outline in, for nurses (B.R.), 595
One-man pneumothorax apparatus, 140
Operations upon liver, kidney and spleen, electrosurgery as hemostatic instrument in, 540
Operative arthrodesis of the spine, 341
gynecology (B.R.), 594
Orthopedic surgery, treatise on (B.R.), 383
Outline in obstetrics for nurses (B.R.), 595
Ovarian graft in the uterus, 305
Ovary, right, malignant papillary adenocystoma of, with metastasis to cervix, 352

Paleopathology, studies in, xxviii (B.B.), 587
Papilloma, benign, of renal pelvis, 576
hypernephroma, and stone occurring in horse-shoe kidney, 487
Pathology, bladder tumor, clinical application of, 67
of diabetes mellitus (B.R.), 383
of surgical tuberculosis, observations on, with particular reference to incidence of tuberculous bacilluria, 514
Pelvis, renal, benign papilloma of, 576
Perforated typhoid ulcer closed by primary enterostomy, 149
Peritoneum, clinical study of abdominal cavity, and, 167, 385, 597
redundant, and sac, exteriorigation and utilization of, in radical treatment of inguinal hernia, 130
Pessary, gold spring, complications following use of, 143
Physicians and surgeons and their mutual relations, 1
Physiology, chemistry, and, of calcification, 530
Poisoning, lead, and the eighteenth amendment, 32
Polyp, cervical, carcinomatous degeneration of, 136
gastric, prolapse of, into duodenum, with marked secondary anemia, 355
Porro-Cesarean section, bloodless modification of, 299
Postoperative eventration, 78
Practical medical dictionary (B.R.), 382
midwifery for nurses (B.R.), 594
treatise on diseases of digestive system (B.R.), 593
Pregnancy with bilateral ovarian cysts, 338
Present status of electrosurgery and diathermy in treatment of diseases of genitourinary tract, 116
Prolapse of gastric polyp into duodenum with marked secondary anemia, 355
Pseudoarthrosis, tibial, Mommsen's method of submaximal stimulation for, 366

Radiations, ultraviolet, and their uses (B.R.), 166
Radiology, American Journal of Surgery's Contribution to, in 1930 (E.), 583
theory and practice of (B.R.), 591
Third International Congress of,—Paris, July 27–31, 1931 (E.), 375
Razumovsky, V. I., fiftieth jubilee of the social and scientific activity of the Emeritus Professor of Surgery (B.B.), 378
Reconstructive surgery in progressive facial hemihypertrophy, 439
Rectum, anus and, benign lesions of, 255
and carcinoma of, 547
Regional anesthesia as applied to urological surgery, 325
Reminiscences of George Martin Koher (B.R.), 383
Repair of lacerated post-partum cervices in primipara, technic of, 557
Rickets, suggestion of, in the Pleistocene (B.B.), 162
Roentgen significance of gas under the diaphragm, 93
Roentgenological study of the superior and posterior mediastinum, 452
Rose and Carless' manual of surgery for students and practitioners (B.R.), 382

Sac and redundant peritoneum, exteriorization and utilization of, in radical treatment of inguinal hernia, 130
Salpingitis, tuberculous, 331
Sarcoma, bone, *x*-ray diagnosis of, by mail (E.), 157
Section, Porro-Cesarean, bloodless modification of, 299
Sinusitis, chronic nasal, and its relation to general medicine (B.R.), 166
Skin clamp holder, 142
clip forceps, 350
diseases of (B.R.), 382
Some observations in calcium fixation, 294
Spine, manipulative treatment of chronic arthritis of, 285
operative arthrodesis of, 341
Spondylolisthesis, 521
Stomach, diet after operations on, 448
Stone, papilloma, and hypernephroma occurring in horse-shoe kidney, 487
Story of a surgeon (B.R.), 590
Studies in paleopathology, xxviii (B.B.), 587
Suggestion of rickets in the Pleistocene (B.B.), 162
Surgeon(s), physicians and, their mutual relations, 1
story of (B.R.), 590
Surgery, emergency (B.R.), 591
minor, and bandaging (B.R.), 384
orthopedic, treatise on (B.R.), 383
reconstructive, in progressive facial hemihypertrophy, 439
Rose and Carless' manual of, for students and practitioners (B.R.), 382
of the sympathetic nervous system, 8
urological, regional anesthesia as applied to, 325
Surgical goiter, 482
procedures, consideration of, in treatment of malignant disease of urinary bladder, 69
treatment of chronic empyema, 472
Sympathetic nervous system, surgery of, 8

Technic of routine primary repair of lacerated post-partum cervices in primipara, 557
Teleradiographie—Stereoradiographie (B.R.), 594
Telesteroroentgenography, 499
Text-book of gynecology (B.R.), 592
Theory and practice of radiology (B.R.), 591
Therapy, colonic, 496
Third International Congress of Radiology—Paris, July 27–31, 1931 (E.), 375
Thomas splints, improved foot support attachment for, 562
Thrombo-angiitis obliterans, alcohol injection of nerve roots for, 107
Tourniquet, new surgical, 349
Toxemia, intestinal (B.R.), 593
Tract, urinary, tuberculosis of, 308
Traumatic avulsion of tibial tubercle, 577
Treatise on orthopedic surgery (B.R.), 383
Treatment, diagnosis and, of tuberculosis of genital tract, 84
early, of congenital dislocation of hip at the Istituto Ortopedico Rizzoli (E.), 369
injection, of varicose veins, 19
manipulative, of chronic arthritis of the spine, 285
of peptic ulcer, 97
surgical, of chronic empyema, 472
Trendelenburg Position (Bi.B.), 586
Tubercle, tibial, traumatic avulsion of, 577
Tuberculosis of genital tract, diagnosis and treatment of, 84
of urinary tract, 308
Tuberculous salpingitis, 331
Tumors, benign, of hepatic flexure, 573

Ulcer, peptic and appendicitis, chronic differential diagnosis of, 274
treatment of, 97
perforated typhoid, closed by primary enterostomy, 149
Ultraviolet radiations and their uses (B.R.), 166
Ureter(s), complete accidental cutting of, during laparotomy with non-surgical anastomosis, 571
double, interpretation of, 122
Urinary tract, tuberculosis of, 308
Urographic medium, new—emulsified campiodol, 320
Urology in children, 358
Uterus, ovarian graft in, 305

Utilization, exteriorization and, of sac and redundant peritoneum in radical treatment of inguinal hernia, 130

Veins, varicose, injection treatment of, 19

Visualization, blood vessel, new method of (arteriography; veinography; angiography) in vivo, 225

Watson—Williams, Patrick, 166

(Die) Wirbelbrüche und ihre ergebnisse (B.R.), 593

X-ray diagnosis of bone sarcoma by mail (E.), 157

Zoology, elementary, for medical students (B.R.), 384

AUTHOR INDEX TO VOLUME X

Aitkin, Robert, 166
Alvarez, Walter C., 444
Andresen, Albert F. R., 448
Andrews, George Clinton, 382
Aschner, Paul W., 67

Bailey, Hamilton, 591
Baldwin, J. F., 78
Bames, H. O., 80
Barney, J. Dellinger, 84
Bassler, Anthony, 593
Berkheiser, E. J., 294
Bessesen, Daniel H., 472
Bland-Sutton, Sir John, 590
Borradaile, L. A., 384
Bower, John O., 469
Brav, Ernest A., 285
Brockman, E. P., 166
Brown, Samuel, 452
Buckstein, Jacob, 355
Burns, J. C., 469
Butterfield, P. M., 358

Caldwell, Guy A., 562
Case, James T., 159, 375, 583, 584, 592, 595
Coley, William B., 157
Crossen, Harry Sturgeon, 594
Curtis, Arthur Hale, 592
Cutting, R. A., 255, 547

Davis, A. Hobson, 166
De Courcy, Giles, 299
De Courcy, Joseph L., 482
De Vries, John K., 487
Diocles, Louis, 499, 594
Doran, William G., 369

Eiss, Stanley, 338
Elliott, Simeon, 84
Ellis, I. G., 93
Ellis, S. W., 241
Emrich, William H., 564
Ewell, George A., 547
Ewing, Alex. W. G., 383

Finkelstein, Reuben, 97
Fleischman, Abraham G., 116
Flothow, Paul G., 8
Foster, G. S., 305

Garvin, James L., 164
Glasser, S. Thomas, 493
Goldbloom, A. Allen, 274
Goldman, Benjamin, 577
Grandstaff, Floyd T., 300
Gratz, C. M., 341
Grove, Lon W., 149

Harris, Augustus, 362
Harris, R. J., 514
Hartridge, H., 383
Haumann, Walter, 593
Held, I. W., 274
Henline, R. B., 325
Hinton, J. William, 355
Hunner, Guy L., 245
Hunt, Verne C., 69
Hunter, John B., 382

Illievitz, A. B., 56

Jackson, Arnold S., 547
Jenkinson, E. L., 93
Jepson, Paul N., 285

Kamikawa, Kazunori, 225
Kimball, Francis N., 576
Kirschner, Dr. M., 166, 382
Kleinberg, Samuel, 521
Kohn, L. Winfield, 593
Krida, Arthur, 366, 594
Krumbhaar, E. B., 590
Kutzmann, Adolph A., 320

Lambert, Samuel W., 382
La Rochelle, Fred D., 496
Lau, Frederick T., 571
Leggett, Bernard J., 591
Livingston, Edward M., 167, 385, 597
Lloyd, Milton S., 140
Lupton, Charles H., 150

Maes, Urban, 1
Martinon, Antonio Ramas, 573
Massey, Ben D., 245
Matthews, Harvey C., 581
McClure, R. D., 241
McPheeters, H. O., 19
Mengle, H. A. K., 469
Moloney, J. Clark, 349

Moodie, Roy L., 162, 587
Moore, George Albert, 32

Nazaroff, N. N., 378
Nicholson, Daniel, 592
Nordmann, Prof. Dr. O., 166, 382

Pack, George T., 166
Packard, Francis R., 591
Parkes, Wm. R., 63
Partipilo, A. V., 35
Pearse, Herman E., 540
Peters, John P., 530
Phaneuf, Louis E., 352
Potter, Caryl, 143
Putti, Vittorio, 591

Reineke, Harold G., 452
Rice, F. W., 595
Rucker, M. Pierce, 53

Saito, Makoto, 225
Sauer, Paul Kurt, 564
Schmitt, Alfred, 349
Secor, William Lee, 344
Solomons, Bethel, 594
Sondern, Frederick E., 592
Soresi, A. L., 130
Stedman, Thomas Lathrop, 382
Stein, Arthur, 136, 331
Stern, Elias L., 107
Swift, George W., 350

Thomas, B. A., 308

Updegraff, H. L., 439

Von Eiselberg, A., 595

Wakely, Cecil P. G., 382
Ward, Grant E., 540
Warren, Shields, 383
Watson, J. Laxton, 84
Welton, T. S., 161, 377, 586
Wershub, Leonard Paul, 122
Whitman, Royal, 383
Williams, E. G. C., 142
Williams, Gwynne, 384
Williams, J. Whitridge, 384
Wright, Wilmer Cave, 594
Yanagizawa, H., 225

Young, James K., 384